THE DENTAL PRACTITIONER

AND DENTAL RECORD

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THE DENTAL PRACTITIONER
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Vol. VIII, No. 3 November, 1957

EDITORIAL

WINDSCALE

THE unprecedented news that a Russian dog had been propelled into space in a satellite brings forcibly to mind the rapid and gigantic changes taking place in the world. Coupled with the unfortunate incident in the atomic pile at Windscale, we are suddenly brought up against the possible dangers and hazards of this new atomic age. It is therefore imperative that every opportunity be taken to enlarge our knowledge of the problems that may confront us in the future. The occurrence at Windscale brings sharply into focus not only the speed and suddenness with which these problems must be faced but the ideal opportunities that occur for immediate research—research, in fact, of tremendous practical importance. "It is an ill wind that blows nobody any good", and it is to be hoped that the opportunity for research during these first few days have not been missed. Experiments on animals with radioactive milk may be conducted in a laboratory, but here by an unfortunate accident it was happening to a section of the population. Radioactive material absorbed into the body would undoubtedly be absorbed into the teeth and would probably remain in the dentine longer than anywhere else in the body. The importance of dental research becomes obvious. Research could have been instituted immediately on the effects of the passing of radioactive material over the enamel and on the systemic absorption into the dentine. This would have required organization, as all extracted teeth during these few days and the naturally shed deciduous teeth would have had to be examined. A special check would have had to be made later on the children being bottle fed at that time, particularly on children under twelve months with unerupted teeth, and the teeth collected when they are shed. We trust that the incident at Windscale will never happen again, but if a sudden opportunity for research of this nature is presented we must be prepared. Some sort of research group committee should be set up under an existing authority who would be ready to move at a moment's notice to take over large-scale research into this type of problem. The dental profession must shoulder this responsibility themselves, for not only will the information be invaluable, it will raise the status of the profession and ultimately convince everybody that we have a greater function in the life of the nation than merely looking "down in the mouth".

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FINISHING AMALGAM RESTORATIONS

By G. F. KANTOROWICZ, B.Sc., L.D.S. R.F.P.S. (Glasg.)
Lecturer, Conservation Department, The Royal Dental Hospital of London, School of Dental Surgery, London

In 1908 G. V. Black wrote: "Fillings properly made of amalgam are a close second to a gold foil in their durability and in their protection against the recurrence of caries. It is more difficult to learn the manipulation and even then it is more difficult to secure perfect results, filling after filling." Much has been written about cavity preparation and the manipulation of amalgam. These are, of course, of basic importance, but there are other aspects of the amalgam technique which are often neglected, and it is to the matrix band, the contour, and the polish that I propose to confine my attention in this article.

THE MATRIX BAND

It has long been generally accepted that a matrix band is essential to the production of a satisfactory amalgam restoration of proximal areas. It is, therefore, all the more surprising to find a modern author advocating a method which dispenses with the use of a matrix band (Philipp quoted by Rebel, 1947). The importance of the matrix is that it provides a fourth firm wall against which the plastic filling material can be adequately condensed to give a well-adapted homogeneous filling to the correct form, and to maintain this during the initial stages of setting. The band should be thin enough to keep the space between the filling and the adjacent tooth to a minimum, but too thin a band will yield excessively under the pressure used during condensation, resulting in overhanging gingival margins and poor proximal contour. It should be withdrawn buccolingually whenever possible to avoid disturbing the contact area.

In casual conversation one often speaks of contact *points* in connexion with the interproximal contact of teeth, which may mislead one into thinking of a contact similar to that which exists between two spheres. This is manifestly not so; all teeth have considerable contact areas and these areas, in posterior teeth particularly, constitute a considerable part of the proximal surface. It is therefore usually necessary to reproduce a contact area rather than a contact point. A matrix band which is too thick, i.e., more than approx. 0·002 in., is unsatisfactory because upon the withdrawal of the band the amalgam filling may not be in contact with the adjacent tooth. A small gap, which may in this case result, is dangerous because it is not large enough to be self-cleansing and will provide an area for food impaction with its pathological sequelæ. "A large self-cleansing area between two teeth, accessible to the toothbrush, or none at all" must be the rule when restoring proximal cavities. A satisfactory universal matrix band, which can be applied to every cavity and which can be withdrawn buccolingually and occlusally, has yet to appear, and it is therefore necessary to have at one's disposal several types of matrix bands. I suggest one should have not only the several types of matrix bands commonly sold on the market, but also rectangular strips of stainless steel of various dimensions, and copper rings which can be adapted to act as matrix bands.

Wedges.—Close adaption of the matrix band to the tooth at the cervical margin is essential. In many cases this is possible by the use of the right type of matrix band. On the other hand, in the majority of cases this is not possible without the use of a wedge. When a matrix band is fitted to the tooth, leaving a potential gap between the metal and the cervical margin, and the amalgam is condensed in the cavity, the result is usually an excess of amalgam at the cervical margin of the filling, and inadequate condensation of the cervical portion. This is a common fault in amalgam fillings and can be prevented by the correct use of wedges.

The wedge serves two purposes:—

1. To adapt the matrix band closely to the cervical margin of the cavity in the tooth.

2. To make use of the resilience of the periodontal membrane to obtain a small space which, on withdrawal of the matrix band, will be closed again, thus ensuring a contact area.

A variety of wedges can be made from an ordinary wooden tongue spatula, the average thickness of which is 2 mm. Different shapes and sizes of wedges can be cut with a knife, and they have the advantage of being economical as well as efficient. A wedge of this type, of triangular cross-section, will, when properly inserted, press the matrix band against the tooth to be filled, while the other side presses the adjacent tooth away within the limits of the physiological movements of the tooth. This will compensate for the space occupied by the matrix band during the packing of the amalgam. On withdrawal of the wedge and the matrix band, the adjacent tooth returns to its normal position, ensuring a contact area. The base of the wedge rests firmly on the soft tissues (*Fig.* 1).

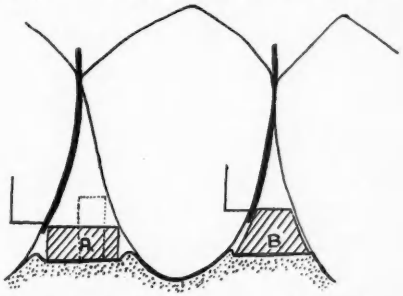


Fig. 1.—Wedge A may turn over at the critical moment because it is rectangular, thus leaving a gap cervically between the matrix band and the tooth. Wedge B rests firmly on the gingiva, and because it is triangular it is in contact with the adjacent tooth, pressing the matrix band firmly against the tooth.

The celluloid wedge of rectangular cross-section is often of little use because it *is* rectangular. Since it is not thick enough in one dimension, and is in no way fitted to the inter-dental space, it may turn over at the critical moment when pressure is applied. Wedging is essential in wide cervical cavities and at times it may be necessary to employ two wedges—one applied from the buccal side and one from the lingual side of the tooth. If the flat, plastic wedge is used, pressure against the matrix band often occurs only at one point, leaving the buccal and lingual cavo-surface angles free. It is admitted, however, that wedging in deep cervical cavities is extremely difficult, if not impossible. Wedging is generally indicated in all interproximal cavities, including Black's Class III cavities where a metal matrix band is used.

Mention must be made of Hollenback's matrix for interstitial cavities (Hollenback, 1937). Briefly described, it is a thin stainless steel band 0·0015 in. in thickness, placed in position and wedged, buccally and lingually, at the gingival margins. It is rectangular in shape, and extends no more than 2 mm. beyond the buccal and lingual margins of the cavity. A small amount of low-fusing modelling compound is softened and pressed into the buccal and lingual embrasures to reinforce the matrix (*Fig.* 2).

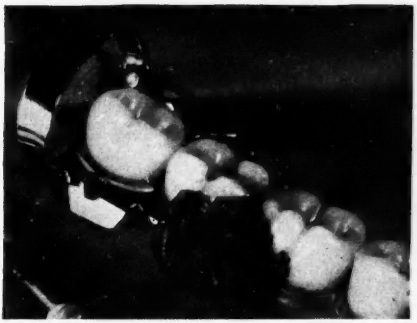


Fig. 2.—Hollenback's matrix. The metal strip is reinforced and wedged by composition.

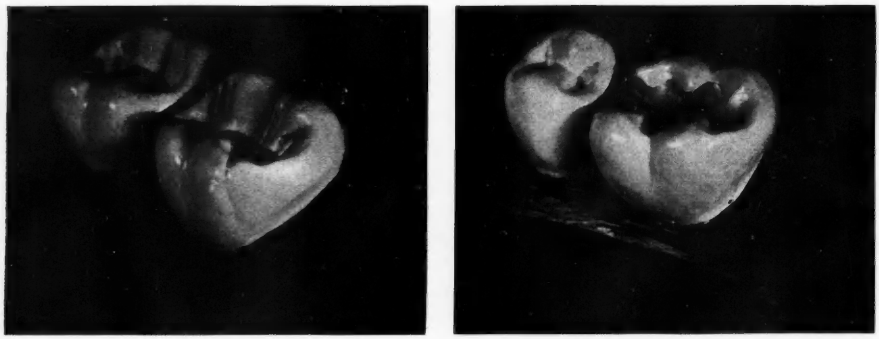
THE CONTOUR

The literature on the subject of contouring amalgam restorations seems divided. The American literature reveals an almost dictatorial attitude, demanding that the filling must be contoured to reproduce the exact anatomical features of the tooth. The justification of this is based on æsthetics and function, and appears to disregard the mechanical disadvantages. Continental authors do not consider this necessary, however, while some British writers are in favour of, and others opposed to, the exact reproduction of the normal anatomy of the tooth.

The function of contouring an amalgam filling is two-fold:—

1. To obtain good occlusion combining maximum function with strength.
2. To prevent retention of food debris in interproximal areas.

In the restoration of a tooth, a filling should be constructed to give the maximum contact in functional occlusion. Particular care should be taken to ensure that the filling does not interfere with any excursive positions. The marginal ridge should normally be restored to the same height as the marginal ridge of the adjacent tooth; but in cases of over-eruption which are not too severe, the opposing cusp should be ground down with a stone to establish normal occlusion. If the ridge is too high it may be broken off either by the matrix band during withdrawal or by the patient biting on it. On the other hand, if it is too low, it may lead to impaction of food in the interproximal areas. Only in cases of severe over-eruption of a tooth may the marginal ridge be adjusted to follow the general pattern of the occlusion rather than be restored to its correct height. The marginal pit is another anatomical feature which should be reproduced when contouring a filling to ensure that food is deflected into the embrasures and on to the occlusal surface of the tooth rather than into the interproximal spaces. When the marginal ridge is adjusted because of over-eruption of an opposing tooth, care must be taken to reproduce the marginal pit.

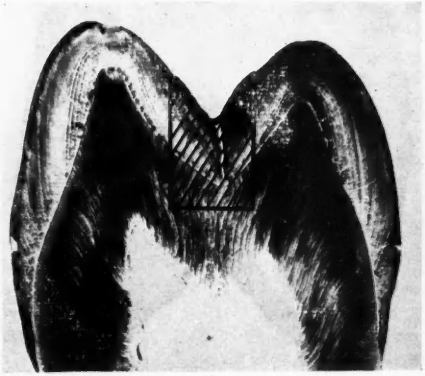


A B

Fig. 3.—A, An amalgam restoration contoured to reproduce the anatomical features of the tooth. B, A similar restoration to A, simulating rather than reproducing the anatomical features, giving the restoration added strength.

Maximum strength of the filling is certainly not the result of exact reproduction of the anatomical features of the tooth which the amalgam replaces. The carving of deep fissures will only weaken the filling and may result in fracture. The only exception here is when part of the fissure in the tooth has not been cut out. In these cases the enamel fissure must be continued in the amalgam to ensure close adaption of amalgam to enamel. It is important to simulate rather than reproduce the exact anatomical features of the tooth when restoring it with an amalgam filling, in order to obtain maximum strength. Hallett's detailed analysis of this subject need not be repeated here (Hallett, 1944), but it must be remembered that over-contouring may lead to early destruction of an otherwise perfect filling. Simon (1956) stresses that the lost anatomy of the planes of the tooth should be restored, but not necessarily the deep grooves and fissures. Theoretically, a flat surface gives maximum marginal strength to a filling. In occlusal fillings it may sometimes be permissible to have a flat surface, but generally the method of choice is to simulate the occlusal anatomy of the tooth. *Fig.* 3 shows the weakness caused by reproduction of the anatomical features compared with a functionally and æsthetically satisfactory restoration which is superior in strength. *Fig.* 4 is a cross-section through a fissure of a

premolar. *Fig.* 4 A shows the outline of an occlusal filling contoured to reproduce accurately the anatomical outline of the occlusal surface, leaving the margins of the filling weak. *Fig.* 4 B shows an occlusal filling with a flat occlusal surface which should result in a filling of maximum marginal strength, but



A

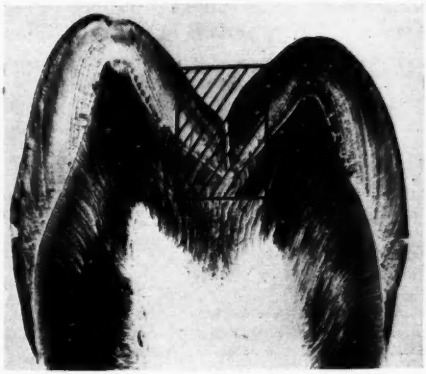
will most probably lead to occlusal interference unless the opposing tooth is ground down, a procedure which might otherwise have been avoided. Furthermore, such a flat surface has an unnatural and unorthodox appearance. The question is whether one should accept the poor appearance modifying the occlusion accordingly, or resort to a weak filling with a contour retaining the anatomical features of the tooth.

In my opinion a compromise between the extremes is the answer. *Fig.* 4 C shows a filling where the marginal strength is maintained and the anatomical outline of the tooth simulated, avoiding occlusal interference.

THE POLISH

Although amalgam fillings will always tarnish in time, the danger of corrosion is always present and must be reduced to a minimum. The more homogeneous the amalgam, the greater will be the resistance to tarnish and corrosion. But the dental amalgams lack the structural homogeneity to ensure tarnish and corrosion resistance. The homogeneity of amalgam can be greatly increased by proper mixing and condensing. Thorough polishing will increase the resistance against corrosion, although the surface may still tarnish slightly (Skinner, 1954).

Without going into the details of the theory of corrosion, I wish to stress that a filling with most of its surface polished, and part not polished, is as susceptible to corrosion as one



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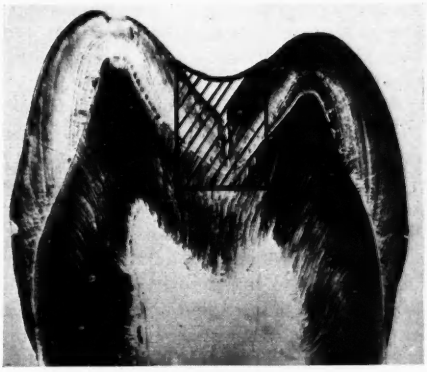

C

Fig. 4.—A ground section of a premolar with a filling superimposed. A, A filling contoured to reproduce the anatomical features of the tooth; B, A flat occlusal surface; C, A modified contour with strong marginal edges of the filling.

which has not been polished at all. In such cases, the unpolished and the polished surfaces act as electrodes in a voltaic cell with the saliva acting as the electrolyte. The polished surface thus corrodes. When this surface is corroded more than the unpolished surface,

the polarity reverses and the process continues—the unpolished surface becomes the negative electrode and corrodes further.

It is therefore desirable to polish every amalgam filling. A further very important consideration is the fact that it is smoother to the tongue and less likely to have food sticking to it, thus enabling the patient to maintain a high standard of oral hygiene.

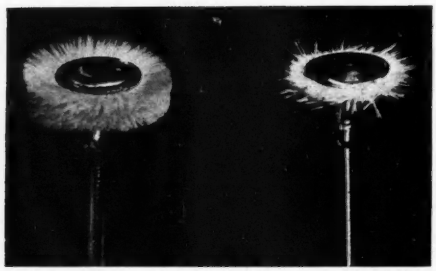

Fig. 5.—The goat-hair brush (*left*), compared with the natural-bristle brush after 30 minutes' constant use.

A well-condensed filling does not require much polishing. Finishing burs and fine grit stones will remove most of the scratches and rubber-pumice may be used subsequently. Hollenback recommends a soft-bristle brush and dry chalk for the final polish (Hollenback, 1937), but most authors agree that the filling should not be polished dry because it may bring the mercury to the surface and the heat developed may damage the pulp. A good polish is obtained with a brush and zinc oxide and alcohol. Most brushes on the market are made of bristle or nylon and are too hard for this purpose. I have found the most suitable ones to be goat-hair brushes. These are now available in this country. Their durability and flexibility far exceed both the natural-bristle and nylon brushes (*Fig.* 5).

An experiment with various types of brushes showed the advantage of the goat-hair brush over the natural-bristle brush. For this experiment three blocks of amalgam, equal in size, were packed by the same method, at the same time, and amalgam from the same mix was used. One was left unpolished as a control, the other two were polished for one minute with finishing burs and with a rubber cup for a further minute. One was then polished with zinc oxide and alcohol and a goat-hair brush, while the other was polished with zinc oxide and alcohol and a natural-bristle brush.

The surface of the three amalgam blocks showed clearly that the goat-hair brush leaves a smoother surface on the amalgam after polishing than the bristle brush.

The contact area presents some difficulty with regard to polishing. In spite of the fact that it requires to be smooth and highly polished, almost more than other parts of the filling, because it is here that the adjacent tooth often develops another interstitial cavity at a later date, it is still impossible to give it the final high polish it requires, until the contiguous cavity is prepared. A new matrix band theoretically provides a highly polished surface against which the amalgam is condensed. In practice, however, the proximal part of a filling is never as highly polished as a well-finished occlusal surface. Occasionally it is possible to insert a narrow linen strip of fine abrasive between two teeth below the contact area and obtain a fairly good polish, but never a high polish. Separating the teeth with a view to polishing the contact area is possible, but uncomfortable to the patient, time-consuming, and dangerous to the periodontal membrane. It is in this area that caries recurs so often, either on the adjacent tooth or at the margins of the cavity preparation. Our present standard of polishing the proximal surface of a filling is, in my view, inadequate and requires further investigation.

FAULTS AND FAILURES

Investigation of the cause of failure in 1521 defective amalgam restorations showed that:—

1. 56 per cent were caused by defective cavity preparation.

2. 40 per cent were caused by faulty manipulation of the amalgam or its contamination at the time of insertion.

3. 1·2 per cent required replacement because of morbid effects on the pulp and/or the periodontal tissues. Abnormal proximal contour and cervical excess came into this category (Healey and Phillips, 1949). The remaining 2·8 per cent were probably due to unclassifiable causes.

Another investigation of 274 amalgam fillings involving a proximal surface showed that 89 per cent were faulty on the proximal surface. Some had faulty contour, some faulty

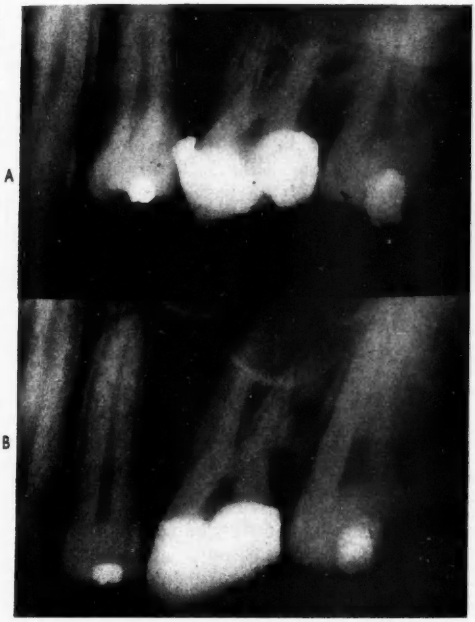

Fig. 6.—An amalgam filling in $\underline{6}$. A, Cervical excess of amalgam, no contact area. B, Cervical excess removed, contact area restored.

contact, and most of them had an excess of amalgam at the gingival margin. According to Easton most of these faults could have been prevented by the correct use of matrix bands (Easton, 1941).

Faulty adaption of a matrix band only too often leads to an excess of amalgam at the cervical margin (*Fig.* 6). This can sometimes be removed with a concave flame-shaped finishing bur or a small fissure bur, or by the use of hand instruments. More frequently, however, the only means of rectifying these faults is removal and replacement.

If, after the removal of the matrix band, a contact area has not been achieved, the filling should be removed, preferably before it has set, and the matrix band modified before being re-applied, or a different type of matrix band selected. In the case of very wide cavities, it may be permissible to leave the amalgam to set, and after at least 24 hours a new cavity can be cut in the proximal part of the amalgam filling, leaving some old amalgam at both the buccal and lingual cavo-surface angles. A good undercut and occlusal dovetail is necessary for this. But, if the cavity is not sufficiently wide, the operator may be left with an abnormal bulge constituting the contact area. This will only lead to an early fracture of the filling. The addition of little pieces of amalgam to the filling in order to restore the contact area is bad practice. This will only produce a contact area which is too high and weak.

Food impaction, if not caused by the absence of a contact area, is often caused by the absence of a marginal pit or marginal ridge.

SUMMARY

Some aspects of the matrix band are illustrated. Types of wedges have been mentioned and their use discussed. The importance of simulating the anatomical features rather than their reproduction has been mentioned in connexion with the contour of amalgam restorations. Protection against corrosion is the main reason for the high polish, and a new brush for this purpose, the goat-hair brush, has been described. Finally, some common faults and their elimination have been discussed.

I should like to express my thanks to Mr. Stallwood for the preparation of the models, and to the Photographic Department of the Royal Dental Hospital School of Dental Surgery, London, for some of the photographs.

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ELECTRO-FORMED COPPER DIES FROM IMPRESSIONS IN ELASTIC MATERIALS

By S. L. PEARSON, B.D.S.

INTRODUCTION

THE advantages of copper dies are now well recognized, and techniques for their production have been described on several occasions.

Rosenstiel (1950) reviewed the literature and made suggestions for the production of copper dies of individual teeth from composition impressions.

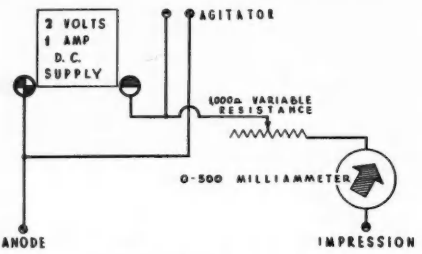

Fig. 1.—Electrical circuit.

Hampson (1952) reviewed the methods of Dwight and Rosenstiel for the copper plating of reversible hydrocolloids, and described a modification of their technique.

The introduction of the rubber-base impression materials provided us with a material of considerable accuracy and stability for bridge and inlay work by the indirect technique, but some difficulty was experienced at first in copper plating these materials.

Skinner (1955) discussed the difficulty he encountered in copper plating rubber-base materials and claimed that the die produced was invariably distorted.

The purpose of this paper is to describe a method of copper plating rubber-base impressions of teeth prepared as bridge abutments and to demonstrate the accuracy of the dies so obtained.

EQUIPMENT

1. The Electrical Circuit.—*Fig.* 1 shows the electrical circuit employed.

The 2-volt, 1-ampere source of current may be in the form of a battery, a suitable transformer and rectifier, or a small battery charger.

2. The Plating Bath.—The bath (*Fig.* 2) is 15 in. long × 4 in. wide × 5½ in. high, with a tight-fitting lid to prevent evaporation of the electrolyte, made in ¼ in. perspex sheet. This tank provides for a distance of 12 in. between anode and cathode, which gives a more even coverage than a shorter distance.

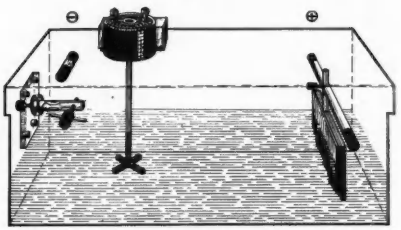

Fig. 2.—Plating tank.

The bath is traversed at one end by a stainless steel rod, secured by a knurled screw at each end. A rod carrying the anode passes through a hole in the centre of this stainless steel rod, and can be clamped at the desired height by means of a knurled stainless steel screw. The anode should be of pure copper.

A 1¾-in. stainless steel rod, containing a vertical hole ½ in. from the end, split for half its length, and traversed by a clamping screw, projects from the other end of the tank. The impression-tray handle is held in a modified stainless steel film clip, to which is welded a stainless steel rod with a ¼-in. ball at the end. This clip is clamped in position by passing the ball into the hole in the split rod and tightening the screw (*Fig.* 3). A stainless steel terminal is provided on the side of the bath at the same level.

The negative and positive leads of the electrical circuit are connected respectively to this terminal and the rod carrying the anode.

A small electric motor attached to the lid of the tank drives a light plastic propeller in close proximity to the impression. This agitator prevents a drop in ionic concentration

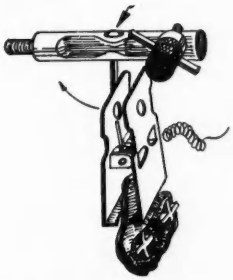

Fig. 3.—Stainless steel clip carrying impression tray positioned in clamp.

at the surface of the impression as plating progresses.

3. The Electrolyte.—The bath is filled for a depth of about 2 in. with an electrolyte of the following composition:—

Copper sulphate	210 g.
Sulphuric acid (conc.)	128·8 ml.
Ethyl alcohol	5 ml.
Distilled water	1400 ml.

TECHNIQUE OF PLATING

1. Preparation of Impression Surface.—An aluminium filled base plate tray is used for taking the impression, as described previously (Pearson, 1955). Recently, however, new cements have been introduced which, when painted over the inner surface of the tray before filling with the material, prevent the impression from pulling away from the tray. It is therefore no longer necessary to perforate the tray to provide retention for the material.

Excess material is trimmed flush with the periphery of the tray with a pair of sharp scissors.

One end of a 12-in. length of fine insulated copper wire is bared for a length equal to the perimeter of the tray, and then commencing opposite the handle it is affixed to the periphery of the tray with small blobs of sticky wax at ½-in. intervals. The wire is then carried over the tray and along the handle and sticky-waxed in position.

Using a camel-hair brush the surface of the impression is washed with a detergent and thoroughly rinsed under the tap.

A clean camel-hair brush is then dipped in 1 per cent Lissapol solution and wiped over the wet impression to reduce the surface

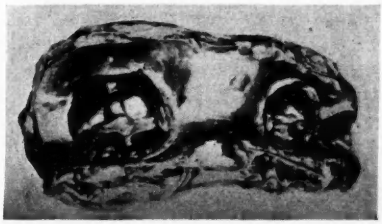

Fig. 4.—Impression, with fine wire attached to periphery, coated with aquadag.

tension. Lissapol is a non-ionic surface active agent.

Aquadag is used to give the impression a conducting surface. As supplied the aquadag is semi-solid in character and should be diluted 1 to 3 with distilled water. The aquadag is applied liberally to the impression surface with a camel-hair brush, care being taken to cover all parts thoroughly. The success of the plating depends on the care with which this operation is carried out. The impression is then dried with a stream of compressed air, a further coat of aquadag applied with equal care, and the impression dried again. (*Fig.* 4.)

2. Positioning of Impression in Bath.—Before immersing the impression and clamping in position it is advisable to vibrate a little of the electrolyte into the impression to avoid trapping air-bubbles. It is important to arrange the impression in the bath so that it directly faces the anode, which is easily accomplished by means of the ball and socket clamping device.

The free end of the fine connecting wire is bared and fastened to the terminal at the side of the bath.

3. Current Density.—Taking a molar space as two units and a premolar, canine, or incisor space as one unit, the variable resistance is adjusted so that a current of 50 mA. per unit is passed. The impression is allowed to

remain in the bath for 24 hours with constant agitation.

THE ACCURACY OF DIES OBTAINED FROM COPPER-PLATED RUBBER-BASE IMPRESSIONS

A brass die was made resembling a molar and premolar crown preparation with a 2° taper. Brass caps were turned to fit these

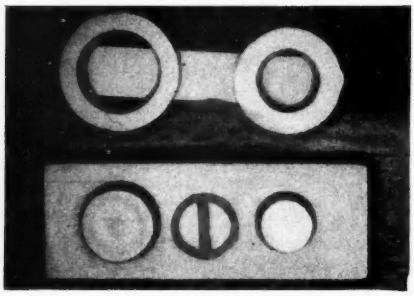

Fig. 5.—Brass die and precision caps.

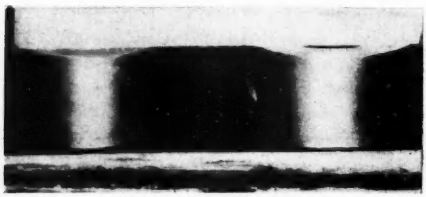

Fig. 7.—Brass caps seated on copper die from static impression of master die.

pillars precisely and joined by a brass bar (*Figs.* 5 and 6).

Impressions were taken of this die in Scania, Flexico, Coe-flex, and Static in an acrylic resin tray.

These impressions were copper plated by the technique described, the plated impressions poured in stone, and the tray and impression removed when the stone had set.

In each case it was possible to seat the joined precision caps on to the copper-plated dies so obtained (*Fig.* 7).

One impression taken in static pulled away from the tray on removal from the brass die. It was pushed back into the tray and plated in the usual way. The brass caps failed to seat properly on the copper-plated die obtained from this impression (*Fig.* 8), indicating the importance of ensuring that the impression is securely held to the tray.

SUMMARY

A technique is described for copper plating rubber-base impressions of one quadrant of the mouth. The importance of carefully coating the surface of the impression with aquadag is stressed.

It is demonstrated that no distortion takes place in rubber-base impressions copper plated by the technique described.

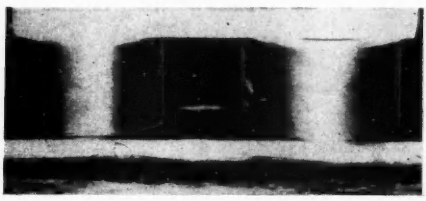

Fig. 6.—Brass caps seated on brass master die.

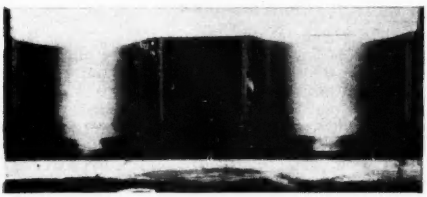

Fig. 8.—Brass caps failing to seat on copper die from distorted static impression of master die.

Acknowledgements.—I should like to thank Professor F. E. Lawton for his advice and guidance, Mr. C. C. Knowles for his assistance with the stainless steel fittings, Mr. D. Allen for making the perspex tank, and Mr. S. Bailie for the illustrations.

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MINISTRY OF HEALTH

Appointment

THE Minister of Health, Mr. Derek Walker-Smith, has appointed Mr. Robert Mathew, M.P., to be his Parliamentary Private Secretary.

THE NON-METALLIC DENTURE BASE—RECENT DEVELOPMENTS*

By D. C. SMITH, M.Sc., A.R.I.C.
Department of Prosthetics, Turner Dental School, University of Manchester

THE whole subject of the plastic denture base is a good example of the need for a more logical and precise approach to dental materials than has been adopted in the past. I am not suggesting that this is entirely the fault of the dentist—there are many influences involved—but the plain fact is that, particularly in this field, the majority of the profession is not clear either as to what it should clinically expect of a plastic denture base material or even as to the limitations of the material which it presently employs. Consider midline fracture for instance: some people see a lot of it, others say they never see one. Neither generally knows why this is so, but the very fact that this does occur shows that the fault lies not in the material but in the way it is handled.

This state of affairs has arisen, I think, principally because genuine progress in this field has been, until relatively recently, only by the tediously slow process of using the mouth of the long-suffering patient as a testing ground. The rapidity of such a method of progress can be seen when one compares the growth and extent of the knowledge of plastics in the past 30 years with the fundamental progress in the denture base material field. I do not think I need to mention that it is over 100 years since the first use of vulcanite, 86 since Hecolite, 29 since Walkerite, 25 since Resovin, and 22 since Kallodent. I am not saying that what is newest is best, but it is unusual for materials to be so widely employed for such a long period with so little *fundamental* investigation on behalf of their users.

May I illustrate this by quoting from a progress report by Sweeney and Schoonover:—"The need for the dentist to have some method other than clinical for judging the relative merits of different materials is apparent to anyone who reviews the literature and who is familiar with the experience of the profession. Failure of so many of the materials sold during the past few years to live up to glowing advertising claims has meant bitter disappointment. During the past ten years more than thirty different trade brands of materials other than vulcanites have been offered for sale to the dentist. The scheme of having the dentist test all these materials clinically has been unfair to both dentist and patient and has been very expensive."

This, I am sure you will agree, sounds very familiar and sums up our problem. Unfortunately it was written over twenty years ago.

It is true that in recent years much work has been done on the physical properties of denture base materials, but many of the reports of this work have been so highly technical as to make it difficult for dentists to interpret in practical terms, and in this country we have suffered from the lack of some specific body to act as such an interpreter and as a watchdog for the profession. Much has been done by individuals, especially in the teaching establishments, but their sphere of activity is necessarily limited, so that of necessity dentists themselves should adopt a more informed and more fundamentally critical attitude to recent developments.

Although methacrylate resin has outstanding qualities compared to what has gone before, the profession is never quite satisfied, and it is criticized as: (a) being liable to midline fracture, (b) producing sore mouth, (c) lacking resilience (low elastic limit), and (d) having low impact strength.

Let us look more closely at these criticisms. What genuine evidence do we have for such complaints, and how far are we sure they are inherent in the material itself?

These faults and the allegedly improved materials which are offered to us can only be judged, I submit, in terms of their clinical suitability, against a background of our

* A paper read before the British Society for the Study of Prosthetic Dentistry, April, 1956.

fundamental requirements, and not by a simple superficial comparison, as is often done.

So, I think, in order to evaluate recent developments we must first consider more carefully than hitherto, in practical terms, our basic requirements before we can say whether or not any proposed change in material or technique is worthwhile or even necessary.

Now the properties of the ideal denture base are often listed, but who will put a numerical value to these qualities which will give them life and meaning? True, there are specifications for acrylic materials, but no one agrees these are the standards to aim at, or that all the important clinical properties are covered. Let us make the problem specific. Of two dentures which were in service for two years, one expanded 0·5 per cent (0·25 mm.) across the posteriors, the other contracted 1·75 per cent (0·76 mm.), yet both were satisfactory in the mouth!

It is obvious that we must ask ourselves the following questions. What dimensional inaccuracy is tolerable clinically? What kind of mechanical properties are required and what is their magnitude? Is a very high tensile strength really necessary? What degree of flexibility, of permanence, of surface detail is required? We cannot say anything which has a practical meaning until we have the answers to such questions.

I need hardly say that it is evident that we lack much of this information, but to establish criteria perhaps we can begin to clarify our ideas and set limits to the more important properties by an actual comparison of suitable plastics in respect of properties which influence clinical behaviour. But before specifying any measurable quantities we must first consider two important points. First, the fact that the properties of plastics depend (much more so than for metals) on the speed and conditions of measurement, e.g., the ultimate strength of a bar of plastic is higher the more rapidly it is stretched. So, secondly, it is very important to decide what method of mechanical evaluation to adopt to assess these materials clinically.

It follows from this time-dependent behaviour of plastics that we can make a valid comparison for clinical use only by testing similarly shaped pieces of material under the standardized service conditions. Obviously a properly organized clinical test using dentures would take years to eliminate all the variables—as indeed it has done—so we must have recourse to testing similarly sized specimens under laboratory conditions.

Now, criticism is often levelled against laboratory tests on the grounds that they are not clinically representative, but providing all the factors which are operating in the mouth are clearly realized, and that the conditions of test resemble those of service (and this is the point which is not always observed), then a satisfactory correlation may usually be obtained. Results obtained in any other way may have little meaning.

This importance of testing conditions must be emphasized. For example, on the grounds of abrasion resistance and resilience under ordinary conditions, nylon seemed satisfactory for posterior teeth, but in service it was disappointing, since surface roughness and burring over of the edges occurred. In this case, since several factors were acting together, it was easier for us to test in the mouth rather than to build a special laboratory machine.

So, our clinical assessment must be based upon properties determined at mouth temperature (37° C.), under wet conditions, and by subjection of the material to dynamic forces.

This brings us to mechanical evaluation. In mastication the denture base is flexed and undergoes a cycle of stress. Excepting semi-accidental causes such as impact, or processing defects, we should expect fractures to be due to flexural fatigue. This is borne out by practical experience. A methacrylate specimen which has been bent once till fracture, shows a typical conchoidal pattern on the fracture surface, which is quite different from the smooth surface of a similar specimen which has failed in fatigue. Dentures which have failed after a period of service usually have a similar appearance to the fatigue specimen, although both types of appearance may be present where a crack has been initiated by fatigue and has then progressed rapidly.

All this suggests that our mechanical criteria should be flexural fatigue resistance and impact strength.

The qualities of importance in a denture base material are to my mind non-toxicity, æsthetic quality, satisfactory strength, dimensional accuracy, and permanence of form.

As *measurable* quantities to be used to reflect these qualities, in the first instance, I wish to use flexural fatigue strength, impact strength, moulding shrinkage (i.e., the linear dimensional change in processing), and water absorption at saturation as a measure of the swelling which may occur and, to some extent, of the relief of internal stress which may occur in service.

If we survey the plastics field for materials which may be satisfactorily made into dentures, we find nylon, methacrylate, polyvinyl chloride (P.V.C.), vulcanite, polystyrene, and polyvinylidene chloride or Saran.

Now we can turn our vague ideas into entities by an actual numerical comparison of each of these materials in respect of the properties just mentioned. Unfortunately there are two further difficulties.

Firstly, there is little flexural fatigue data available; the only numerical strength factor common is ultimate tensile strength which is not directly related. Tensile properties may, however, give a general idea of the character of a plastic. Secondly, most of the data for these properties relate to room conditions.

So most of our previous requirements for a valid comparison are absent, but we must try to make do with what we have at present and see how far we can make a definite assessment for mouth service; we are looking for high strength and low dimensional change, i.e., low moulding shrinkage and low water absorption.

What conclusions can we draw? First, no one material is good in all respects. The materials at each end of the range are outstanding in one or two properties, but deficient in others. From this comparison we would expect nylon to show the higher shrinkage and warpage in service, with vulcanite and polystyrene probably the most stable. Considering the tensile strength we are not sure if the lower value for polyvinylidene chloride is important clinically. Since our information is incomplete we must correlate any predictions with the results of clinical use, for all these materials have been or are being used for denture bases.

Better and more experienced memories than my own will recall polyvinyl chloride as Resovin, Vydon; acrylic vinyl copolymer, Neohecolite, and polystyrene-Tepperite Marvolene.

The present alternatives to methacrylate are (excepting vulcanite) Luxene 44, Jectron, and various types of nylon. The first two originate in the U.S.A. but are used on the Continent.

Luxene 44 was first put into use about 1939 in the U.S.A. It is supplied as a dough or gel containing a polyvinyl copolymer and a minor proportion of methyl methacrylate monomer. The material is injected into a partly filled flask in much the same way as in the Pryor technique, but using a special air gun and technique and cured in nearly boiling water. The final resin thus consists of a complex mixture of methacrylate and the polyvinyl polymer. The material is claimed to be better than methacrylate and the technique is said to eliminate change in vertical dimension and the effects of curing shrinkage.

Grunewald, Paffenbarger, and Dickson (1952) and Allcock and Bevan (1955) have shown, however, that this and similar techniques do not eliminate the dimensional changes. From the data which are available, no significant advantages of this material over methacrylate seem likely.

Jectron is a specially compounded polystyrene introduced in the U.S.A. in 1951. The material is supplied as a precured cylindrical blank which is softened by heat and injected into a special closed flask using a special apparatus.

The material is claimed not to shrink, swell, or warp in service and to have superior physical properties. A systematic study of Jectron or polystyrene has not been published, but, from data given me by the manufacturers, the processing shrinkage is 0·2 per cent (compare Luxene 44 0·2 per cent and methacrylate 0·2–0·4 per cent), the transverse strength is some 10–15 per cent higher than

methacrylate, and the flexural fatigue strength at high rates of flexing and under room conditions about the same. Although alteration of form in service may be less, again, from the present data, it does not seem as if there is enough difference from methacrylate to justify the more elaborate procedure.

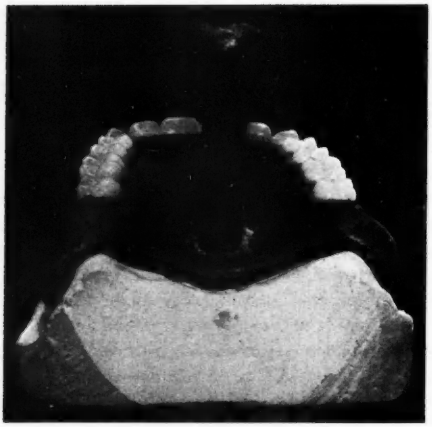


Fig. 1.—Adaptation of a nylon denture.

Now we turn to nylon, which is exciting most interest in this country at the present time. In view of discussion elsewhere I do not think I need labour the questions of the different types of nylon and the factors involved in the injection moulding process. The chief drawbacks of the nylons are their high processing shrinkage which causes poor adaptation, and warpage from the relief of processing stresses which is facilitated by the relatively high water absorption. *Fig.* 1 shows the adaptation of a carefully processed nylon denture to its model. If the denture is sprued to the fitting surface the adaptation after deflasking is better since the shrinkage is directed towards the model, but after service the stresses created are relieved and the adaptation becomes as poor as before. In service deterioration of colour due to a yellowing was observed, perhaps due to bacterial action in view of the protein-like linkages in nylon. The surface could not be as easily or as highly polished as methacrylate, and roughening and ready adherence of deposits were found to occur after some months. The observations and predictions made in earlier articles (Matthews and Smith, 1955 ; Watt, 1955) have recently been largely confirmed in a report of a clinical case by Hallett and Farrell (1956).

For partial use the combination of strength and flexibility weigh against the dimensional inaccuracy. *Fig.* 2 shows the inaccuracy of a commercially produced partial denture. The question of flexibility is a vexed one; personally I think nylon too flexible for the majority of cases. We should not have one set of criteria for metallic and another for plastic partials. The properties of the material suggest that although an inaccurately fitting partial may be forced into place by virtue of the flexibility, the then stressed state will be slowly relieved by a combination of warpage, flow, and tooth movement. From similar causes one would expect the small retentive force of nylon clasps to slowly disappear.

The results of this comparison of plastics provide numerous points of discussion concerning the criteria I originally mentioned, but I have time to mention only three

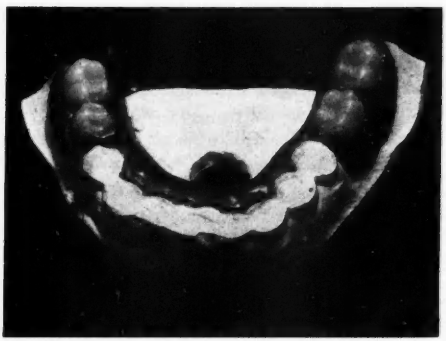


Fig. 2.—Adaptation of a nylon partial denture.

outstanding points. First, given the right data, mouth behaviour of a plastic may be largely predicted, thus saving clinical time and expense. Secondly, these data must be determined under conditions corresponding to those of the mouth. Thirdly, since no one material is perfect, we must set a limited variation in respect of important properties,

and for materials falling within these limits we must make our selection on other grounds.

Pending further data, this leads me to suggest that, given æsthetic quality, a suitable material should have an ultimate tensile strength (as A.S.T.M. D638–49T) of not less than 8000 lb./sq. in., an impact strength

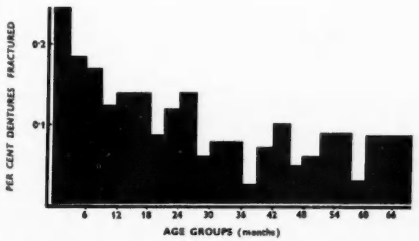


Fig. 3.—Probability of fracture of full upper dentures.

corresponding to an Izod figure of 1·0 ft. lb./in. of notch, a Young's Modulus of not less than 500,000 lb./sq. in., a flexural fatigue resistance to give a life of not less than five or more than ten years, and a total dimensional inaccuracy from all sources of not more than 0·5 per cent.

Against this background let us look at methacrylate, for it is in respect of this material that most recent developments have taken place. However, I should first like to make two important points. First, it seems likely that little increase in the intrinsic strength of plastics is to be expected in the future. Secondly, the three alternatives to methacrylate are produced by three of the world's biggest plastic firms. One might think that if these products have deficiencies there will be small chance of radical improvement in the immediate future.

Since the all-round properties and ease of processing of methacrylate make it equal to or better than these other materials, it seems more logical to see if methacrylate can be improved before introducing new materials which offer new problems. First, let us examine the present position to see what the evidence is for particular mechanical deficiencies in the material and undue tendency to fracture, and secondly, consider whether this is being accentuated by incorrect handling.

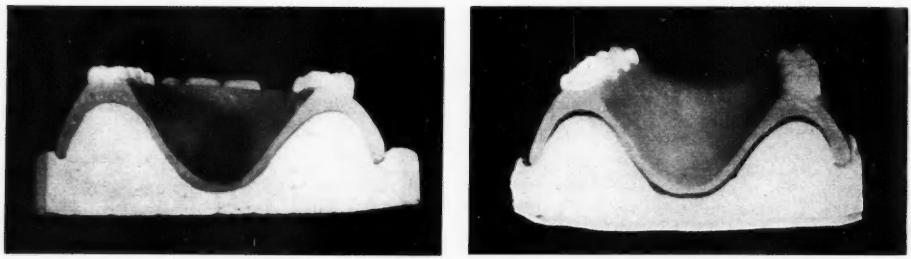
From the hospital records we obtained the statistics relating to the midline fracture of full upper methacrylate dentures which occurred in the period 1949–55. Out of nearly 6400 such dentures only 120 fractures occurred. Nearly all these dentures had plastic posteriors, but so also did the majority of the 6400 dentures. Of these fractures, 24 were shared by 12 patients. The proportionate distribution of the fractures in terms of age at fracture is shown in *Fig.* 3. This shows that a denture has the highest probability of fracture in the first eighteen months of its life and thereafter a much lower figure, allowing all possible causes of failure. This indicates to me that the initial high incidence of fracture is due to extreme causes, e.g., incorrect or heavy bite, deficiencies in denture design (setting up, inadequate relief), poor fit, processing errors, resorption, and so on, all leading to an imbalance of masticatory forces and sufficient flexure of the denture to cause rapid fatigue failure. Leaving aside the small number of exceptional patients, if these avoidable faults are removed, the probability of fracture is reduced to about 0·06, i.e., about 1 in 150–200 dentures. It is interesting to note that short-term failures of vulcanite dentures were also recorded and that there was little bias in the fracture results in respect of age or sex.

If it be kept in mind that the proportion of fractures within the hospital is probably on the high side—two-thirds of the fractured dentures were made by students—then it seems that methacrylate has little to answer for in respect of undue fracture unless its limitations are abused, or the case is one which must be specially provided for anyway.

Two limitations of methacrylate have been the subject of recent work. These are the fit and the completeness of polymerization.

Fit or Adaptation.—It has been known for some time, of course, that rapid cooling of the case after processing produces a stressed denture showing poor adaptation to its model. Both these factors predispose the base to fracture and they are more effective the greater the temperature range through which cooling takes place. Our ideas on the subject have been crystallized by the work of Ryge

and Fairhurst (1954, 1955), Stanford, Burns, and Paffenbarger (1955), Skinner and Jones (1955), and others. The adaptation depends mainly on the rate of cooling and temperature, and less on the curing shrinkage. This may be shown by subjecting a fully cured stress-free denture to various heating and cooling cycles. *Fig.* 4 shows the effect of two common methods of cooling on the same denture. Thus the best fit is obtained by cooling as slowly as possible from a curing temperature of 70° C. Ryge's work has shown how the adaptation is still further improved by using tinfoil instead of alginate as a separator. This difference has been ascribed to surface roughness variation, but the recent work of Brauer and Sweeney (1955) suggests that stresses due to the water absorption permitted by the alginate film may also contribute. This has also confirmed Ryge's (and others') observations that the denture cured against alginate is nearly saturated after curing and the further water absorption does not cause enough swelling to compensate for curing shrinkage.



A B

Fig. 4.—Adaptation of a fully cured stress-free denture after reflasking, reheating, and (A) bench cooling from 70° C., (B) rapid cooling in cold water from 100° C.

Commercial attempts to improve adaptation have included the use of a dough which flows very easily, and techniques designed to produce uni-directional curing. There is as yet no evidence of the level of effectiveness of such procedures.

Completeness of Polymerization.—This now raises the question of duration of cure, for the lower the curing temperature the longer it takes, of course, to reach a given level of polymerization of the monomer. The presence of much residual monomer (R.M.) weakens the denture and makes it less heat- and solvent-resistant.

Our method of determination of R.M. (Smith and Bains, 1955, 1956) has been applied to a determination of the R.M. left in the denture base after various cures, and to a fundamental study of the methacrylate polymerization.

The results show that after a long period at a particular temperature an equilibrium is reached in which the polymer contains a small amount of R.M. *Fig.* 5 shows how the R.M. in the denture base falls with time with curing at a constant temperature of 70–72° C. and 1·5 hours at 70–72° C. followed by boiling. If the monomer content is below about 1 per cent the mechanical properties are not substantially reduced. This takes 0·5–1 hour at 100° and about 24 hours at 70° C.

Thus, cures using either of these conditions are equally satisfactory, but on the grounds of adaptation and reduced internal stress also, an overnight cure at 70–72° C. is considered the best. Such dentures will also show reduced fracture incidence and little likelihood of sore mouth (Nyquist, 1952; Van Huysen and Leonard, 1954; Smith and Bains, 1955; Hedegard, 1955).

We have, however, also investigated the possibilities of improving the strength properties of methacrylate by copolymerization and reinforcement.

Copolymerization of methacrylate with other monomers produces a mixed result in that some particular property may be improved (for a particular purpose) whilst others are

made worse, e.g., crosslinking gives sufficient solvent resistance to avoid crazing, but the tensile and fatigue strengths are lowered and there is little practical improvement in water absorption, hardness, and abrasion resistance (Vernon, 1952).

Copolymerization with other acrylic monomers usually gives tougher, more resilient

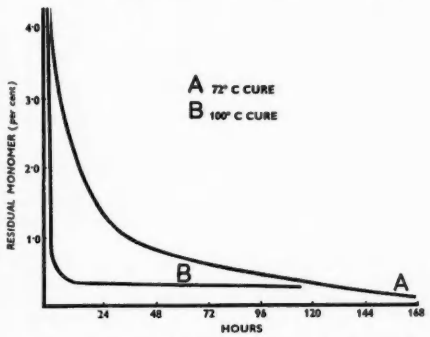


Fig. 5.—Fall in residual monomer in a denture with duration of cure.

products having lowered strengths and heat resistance. Dynamic properties such as fatigue resistance may improve, however (though perhaps not to a clinically important extent), but the observations of Matthews and Johnson (1949) on ethyl-methyl methacrylate copolymers are being taken further. It is too early to draw any definite conclusions, but it is of interest to note that the fatigue failure observed under the conditions being used (slow flexing in water at mouth temperature) is similar in appearance and absence of crazing to that observed in dentures.

Reinforcement of a denture involves using a compatible material, i.e., one which is wetted by the resin, and has comparable physical properties. For these reasons the use of metal and Perlon (a type of nylon) strips and gauze has proved unsatisfactory, since not only are stress concentrations produced but also the plastic is made thinner and repair is only made more difficult.

Glass-fibre, as fibres, mat, or cloth, is now widely used for plastics reinforcement. Leader has of course already used glass-cloth laminates for dentures. We have examined the effect of addition of discrete fibres to the ordinary dough as a simpler procedure. *Fig.* 6 shows how the tensile strength of the cured laminate varies with glass content. The minimum in the curve is considered to be due to the fibres acting as weakening discontinuities until they begin to interact with one another. Not more than about 40 per cent glass can be introduced in this way because of manipulative difficulties, but satisfactory dentures can be produced. The use of glass-cloth which is under development allows incorporation of more glass but creates similar difficulties.

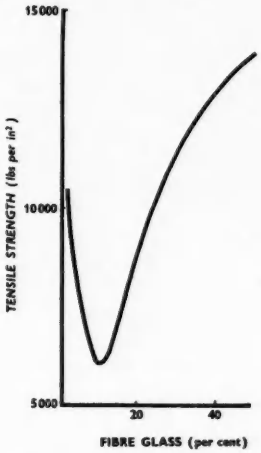


Fig. 6.—Effect of discrete glass-fibre additions on tensile strength of polymethyl methacrylate.

Fibres of other plastics have been used for methacrylate reinforcement, but it is not yet obvious whether any significant advantage obtains.

I have indicated that the all-round superiority of methacrylate makes it the best current non-metallic denture base material, but what of its younger competitors? There are three newer plastics which are of interest. First we have the epoxy resins which are familiar as the amber material used for tool handles. In the preferred form two liquids are mixed to form a fluid casting mixture which may be cured at room-temperature to a tough, insoluble resin, with very little curing contraction. Unfortunately they do not dissolve

included air and the pronounced yellow colour has proved very difficult to mask.

The polyester resins are similarly obtained from liquid casting mixtures, but an initiator and accelerator have also to be added. Although they may be almost colourless, they tend to brittleness. However, they prove excellent laminating agents for glass-fibre giving high strength products containing as much as 60–70 per cent glass. Application to denture base use has proved difficult manipulatively but it is possible that this problem will be solved.

Finally there are the so-called "styrene alloys" in which small amounts of synthetic rubbers have been added to polystyrene. These materials have vastly improved impact strength and toughness, but the tensile strength properties are low and other disadvantages are evident. The precise way in which the rubber is dispersed is not clear, but one suggestion is that minute globules are present whose function is to prevent propagation of any cracks. This same principle may well be applied elsewhere.

In this review I have not had time to discuss each point exhaustively, but I hope I have been able to show the need for a more critical approach in this field, and that there is rather more to the non-metallic denture base than meets the eye.

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STUDIES ON DENTAL CALCULUS FORMATION

A method evolved to produce *in vitro* studies of calculus formation is described. Saliva collected from individuals was pooled and then placed in a separating funnel and allowed to drip into small dish-shaped receptacles in the first of which were teeth, whereas the second, third, and fourth were empty. Samples of untreated saliva, of saliva initially processed by the use of a high speed centrifuge, and of saliva to which the bactericidal substance, Zephiran, was added, were tested.

In a further phase of the experiment five substances (aureomycin; achromycin; varidase (a mixture of streptokinase and streptodornase); wydase (hyaluronidase); and tryptar (trypsin)) were added to the specimens of saliva.

In every case, a soft, light yellow amorphous mass formed under both normal atmospheric conditions and in an atmosphere of reduced oxygen tension in the controls. This precipitate formed in the funnels, on the teeth and in their receptacles. Samples of the precipitate were examined by X-ray defraction and revealed a crystalline structure similar, if not identical, to that of calculus formed *in vivo*, and on histologic examination the stroma was the same as in calculus formed in the mouth.

All the antibiotic substances tested inactivated or eliminated the salivary bacterial flora, completely inhibiting the formation of calculus. Inhibition was also produced when the saliva was sterilized by autoclaving.

This study was part of a thesis and contains a bibliography of 226 references.—RICE, B. H. (1956), *J. West. Soc. Periodont.*, **4**, 103.

DEVELOPMENTAL SUPERVISION OF OCCLUSION*

By **FRANK F. LAMONS**, D.D.S., *Atlanta, Georgia*

DENTISTRY as a learned profession requires of the dentist certain obligations and responsibilities to his patients. In a general way, these obligations and responsibilities may be classified under five different headings:—

1. The responsibility of making a thorough examination at every visit, or at the beginning of each series of visits.

2. A careful diagnosis of existing conditions and the requirements to restore and maintain oral health.

3. The removal of pathology and, as far as possible, the causes of these conditions.

4. The restoration of lost tissue or teeth to adequate function.

5. Instruction of the patient in home care or his part in maintaining good oral health.

These five conditions are true responsibilities for every adult. If the patient is a child, another responsibility must be added. It is that of doing everything possible to help the patient grow up with the optimum of dental and oral development so that he may reach maturity with a sound, well-functioning set of natural teeth.

This sixth obligation and responsibility we may call "developmental supervision".

Developmental supervision requires a careful study of occlusion of the child and a continuous follow-up through the years of growth and development up to maturity. It will require some understanding of the aetiology of maldevelopment and an appreciation of conditions which may be changed to promote more favourable development where indicated.

It is estimated from several studies which have been made both in Europe and the United States that over 50 per cent of children have malocclusion. One study made in the Chicago area by Massler and Frankel showed 78·8 per cent of a group of 2758 children (ages 14–18) with malocclusion that needed correction. Three per cent of this group had ideal occlusion, while the remaining 21·2 per cent were considered normal although they showed minor deviations.

The results of such studies will depend upon the examiner and his ideals of normal occlusion. The fact that all studies have shown over 50 per cent of children with malocclusion would indicate an area in dental practice which should be more fully studied and in which prevention should be practised whenever possible.

The aetiology of malocclusion is apt to become a very complex problem when fully studied. For our purposes today we may divide it into two groups—general causes and local causes.

General causes are those with a genetic background which may be very meaningful to us in the States with our population of mixed origins; also endocrine disturbances, conditions of disturbed growth due to disease, malnutrition or any condition which affects or retards the growth of the individual during his years before maturity.

Local causes may be those due to abnormal habits, premature loss of primary teeth and the young permanent teeth, prolonged retention of primary teeth, poor or inadequate dentistry, especially during the early years, and others which are perhaps familiar to you.

When dealing with those malocclusions of a general aetiologic background, little is offered to the dentist in the way of prevention. We can do nothing to change the genetic background. Improving the general growth and developmental pattern through improved health is always advisable and desirable but may offer little in the way of specific help.

It is in the understanding of local aetiologic factors and in doing something about them that we can employ measures to improve the occlusion and assist in better development.

Developmental supervision, then, becomes a responsibility which the conscientious dentist

* A paper delivered to the American Dental Society of Europe, July 11, 1955.

cannot ignore if he is to faithfully fulfil his obligations to his young patients. Good occlusion means good function. Malocclusion is the result of maldevelopment. It means impaired function. It does not suddenly arise as some acute disease, for there is no such thing as an acute malocclusion. It results from a long period of disturbed growth and development.

Good occlusion and good function are essential qualities in good dental health and the maintenance of this good health.

Occlusion is one of the basic fundamental considerations in the practice of dentistry. It is an important factor in every type of restoration. It must be dealt with in every condition of periodontal involvement. There is never an operation that the dentist performs in which he does not have to consider occlusion and the effects of his operation on future occlusion.

To help our patients grow up with a finer occlusion should be a matter of concern to every dentist and requires close supervision of the development and growth of the jaws and arches at all times.

In all of its authentic literature and by public pronouncement, the dental profession has advocated that the child make his first visit to the dentist not later than at the age of 3 years. This visit should be for the purpose of a thorough examination for caries, enamel defects, soft tissue lesions, stains and calculus and include an appraisal of the occlusion. Even normal appearing occlusion should be studied carefully for minor deviations.

The status of the occlusion should be recorded for future reference. This may be done by written descriptions, by plaster casts, or by photographs. This is the time when developmental supervision of the occlusion should begin.

Small arches and narrow arches may not need immediate care because they can and do grow with advancing age. Some extremely narrow arches can be immeasurably helped by early treatment, or treatment at a later date may be indicated, and the time to institute such treatment can best be determined if growth and developmental progress are closely followed.

Beginning with the complete eruption of the primary teeth (age $2\frac{1}{2}$ to 3) until the age of their exfoliation and replacement by the permanent successors and including the eruption of the second permanent molars represents the span of years in the life of the individual when the local causes of malocclusion are most active in influencing the development of occlusion. It is during this period, then, from 3 to 12 or 14 years of age, when developmental supervision will be of the greatest service; when many conditions of maldevelopment can be corrected or be alleviated and malocclusion prevented at maturity by providing better environment for the sequences of growth and development which are taking place.

Perhaps the most important consideration and the one that we have within our power to do something about is the maintaining of a healthy primary dentition. This means that caries must be combated with all of the methods we have at our command: dietary advice and control, regular prophylactic care, topical fluoride treatments, instruction and follow-up in brushing technique and home care and always restorations to arrest the inroads of caries, and to restore the chewing surface and maintain function.

Good function and exercise in promoting good arch development is a very real factor. It should be a part of our programme for every child to teach him and to have his parents teach him to masticate thoroughly. Too many children fail in this area. They start out nursing a bottle, soon pablum is added, then strained foods follow along with soft cereals. We urge the use of milk for its nutritional value but too frequently it is used to wash down the food so that the child develops the habit of not masticating and thereby a valuable stimulus to arch and jaw development is lost.

Very early in the life of a child the importance of vigorous mastication should be explained to the parents and their responsibility outlined. An excellent way to teach a child good masticatory habits is to teach him to have his meals without liquids. Drink his milk—yes, but either before or after his meal, preferably afterwards. Also, parents should insist that children have with their meals some of the foods which require vigorous mastication.

This is a valuable service which we can render our patients and which should not be overlooked.

The child with carious and badly broken down primary teeth cannot develop good masticatory habits.

Too much importance cannot be attached to the preservation of the first permanent molars. This should mean early attention to the fissures. The early loss of one or more of these teeth, especially before the eruption of the second permanent molar, presents one of the most disturbing developmental problems in the maturing dentition.

The use of the term "sealing" or "to seal up" when describing the operation which should be performed when fissures are present in the permanent molars is recommended. It actually describes the operation performed, is more meaningful to parents, and avoids a disturbance in their minds when told about the necessity for this operation to preserve these teeth.

In the upper permanent molars attention to the fissures is indicated to preserve the transverse ridge, especially in the first permanent molars. We believe this ridge is most important and that it offers a very stabilizing influence on the correct relationship of the lower to upper molar which, in turn, promotes better occlusion.

In a programme of developmental supervision of occlusion, every child should have a full-mouth radiographic survey not later than at age of 6. This is important to establish a base-line record for comparison at later stages of development. Additionally, many anomalies of tooth position, supernumerary teeth, and missing teeth will be discovered, which will enable the dentist to plan future work of great value in assisting the patient to have a better occlusion at maturity.

Traumatic injuries to the anterior teeth are very common. In many instances they go unnoticed except for soreness which is home treated and the dentist is not consulted. This is especially true in the primary teeth. Many times the child does not report the injury or there is much confusion and the parents fail to discover the injury to teeth. Frequently these teeth turn dark, then yellowish, but apparently remain healthy. When this is the case, the roots may become hardened, will not show the normal resorptive processes and the permanent incisors will be deflected lingually as they move down in eruption.

When dark or discoloured primary incisors are discovered, one should become extremely cautious about the exfoliation schedule. Frequent radiographic examination will show failure of resorption; if this is the case, the offending teeth should be removed early to allow the permanent incisors to move downwards and forwards without interference. This is perhaps one of the most frequent causes of inlocked upper permanent incisors. That such a condition interferes with normal development has long been recognized and many methods have been devised for its successful correction. More important is the recognition and prevention of such conditions.

Depressed or submerging primary molars may show at any age up to normal exfoliation time. They create a disturbance in the development. The cause is ankylosis of the tooth in the bony socket and failure of the alveolar process to grow along with that of the adjacent teeth. The aetiology of the ankylosis is unknown. Since they can present serious interferences with development, they require close attention. In some instances, the submerging may be slight and not progressive; if such is the case, the offending tooth may be retained. Bite wing radiographs made at frequent intervals enable the operator to keep close supervision over this condition. If the submerging does appear progressive, the tooth should be removed and a space maintainer employed.

The maintenance of space following the premature loss of primary molars is recognized as an essential service in promoting better development. It has been so fully covered in the literature that for the sake of brevity it does not seem wise to cover the subject in this discussion in any detail. I am sure you are aware of its importance and of the many types of fixed appliances which are available and also of the use of removable acrylic partial dentures where several teeth are prematurely lost.

Prolonged retention of primary teeth is another subject about which a great deal has been written. This condition can be easily overlooked and is thought to be of less importance than the premature loss of primary teeth, but such is not the case. Prolonged retention may be due to a variety of causes. Some may be easily recognized; others will be more obscure. Each patient must be studied on an individual basis. The dentist who is mindful of his obligation in supervising the development of the dentition will find many situations where he will be able to render a valuable service in this area.

Ectopic position of the permanent teeth is a condition which may present many distressing problems if allowed to go unattended. The radiographic survey at the age of 6 or before will establish the positions of the succedaneous teeth and follow-up radiographs will show changes and deviations from the normal developmental pattern which may give the opportunity for interference by the dentist, allowing for improved development. One area in which this condition might be of particular importance is in the position of the upper permanent cuspid. The prolonged retention of the upper primary cuspids has been cited as a cause of lingually impacted permanent cuspids. Maybe it is the ectopic position of the permanent teeth that is responsible for the retention of the primary teeth. In either event, close attention to the eruption pattern as the permanent cuspid moves down may reveal developing conditions which the dentist may improve.

At 7 years of age the upper cuspids are very high and at the level of the floor of the nose. The crown is fully calcified and the root has begun to form. As the root forms, the crown moves downwards and labially. At the age of 9 the permanent cuspids can be distinctly felt on the labial of the alveolar process. We call this the cuspid hump and have come to use it as a diagnostic aid along with the radiographs when determining the positions of these teeth. The absence of the cuspid hump may indicate a lingual position of the permanent tooth.

We have come to feel that the presence of the cuspid hump at 9 to 10 years of age is a diagnostic landmark and can be usefully employed in conjunction with radiographs in determining the positions of the permanent cuspids. When the humps are absent, timely removal of the primary cuspids and—in many instances—the first primary molars can avert the lingual impaction of the permanent teeth.

Abnormal habits have been cited as a cause of malocclusion since dentistry was in its infancy. They present problems which cannot be ignored in helping the patient to have good arches, jaw development and good occlusion. The elimination of harmful habits is seldom a simple matter. They require study, time, patience, and an effort on the part of the dentist, parents, and the child.

Four factors seem important:—

1. The severity of the habit and the amount of pressure will determine the extent of the deformity produced.

2. In individuals where the background predisposes malocclusion, abnormal habits more readily produce abnormal occlusal conditions which the individual might not outgrow.

3. In individuals where the hereditary background is not predisposing to malocclusion, habits must be of an extreme nature to produce a condition which the patient will not outgrow or that will not respond readily to orthodontic treatment.

4. The duration of the habit is a factor to be reckoned with. The longer the habit persists, the more difficult it becomes to correct and the less chance the individual has of outgrowing the deformity produced.

Thumb- and finger-sucking, nail-biting, cheek-biting, lip-sucking and-biting, tongue thrusting, abnormal swallowing, mouth breathing, pressure habits and posture positions all influence adversely the development of occlusion. They must be looked for early in the life of the child and eliminated.

The methods used to eliminate harmful habits are numerous and frequently depend on the personality and the ability of the dentist. This subject has been amply covered in the literature, and it does not seem necessary to discuss the methods which may be

used to correct these habits. I merely wish to emphasize the importance of their correction in a programme of developmental supervision.

A discussion of heredity in the development of occlusion, or its influence on facial development, is a subject within itself. It seems sufficient to point out in this presentation that heredity does have a very great influence on the growth and developmental pattern. Where either or both parents present conditions of malocclusion, such as narrow arches, crowded anterior teeth, prominent cuspids, deep overbites and others, the dentist must be more alert to the aspects of development in the child and more cautious in his study of occlusion as he makes his periodic examination.

The calcification of the third molar begins at approximately 9 years of age. The crown is fully calcified at approximately 12 years of age. Extra-oral radiographs made at 12 years of age will establish a base line for future comparative studies and the means of determining the positions of the third molars as growth and development progress.

Radiographs made at yearly intervals, or more often, tell the story of good or poor developmental progress of the third molars and offer an opportunity to render a worthwhile service by their timely removal before damage has been done.

SUMMARY AND CONCLUSION

It would be impossible to list all of the conditions which may be met with by the family dentist in caring for children, and which can be treated to assist in better growth and development of the jaws and arches, to the end that the individual will have a more perfect occlusion of the teeth at maturity.

It has been my purpose to present enough of the commonplace conditions which are frequently overlooked but which are remedial, and offer help in the prevention of malocclusion.

If I have stimulated your thinking and have caused you to appreciate the fact that our responsibility to children deals not only with fillings, extractions, prophylaxis, etc., but with the important problem of helping their mouths grow up with a better development, then my purpose will have been served and your young patients will receive a better service and you will be a happier practitioner.

For a programme of developmental supervision to accomplish the desired objectives, four conditions must prevail:—

1. It must be interesting to the dentist. Dentists will not do the things they are not really interested in with any enthusiasm. What could be more interesting than helping children grow up with a fine set of natural teeth?

2. It must be beneficial to the patient. If we are good dentists, we believe with all our hearts and souls that a fine set of natural teeth is beneficial, desirable, and worth working for.

3. The parents must have a fine appreciation of the service. They will have this appreciation if you explain your objectives. They will want this for their children.

4. It must be economically sound and profitable for the dentist. It can be, if the dentist is fully aware of the value of the service to the patient throughout his entire life span.

SOCIETY FOR THE ADVANCEMENT OF ANÆSTHESIA IN DENTISTRY

A PRELIMINARY meeting of the Society was held at its headquarters, 53, Wimpole Street, W.1, on August 15, 1957, when Dr. Harold Krogh, of Washington, U.S.A., read his paper on "Intravenous Anæsthesia in Oral Surgery". After the paper a new film was shown entitled "Neraval Anæsthesia", made in Dr. Krogh's office just before his departure. Dr. Krogh's paper and film were received with much interest, as judged by the quality of the discussion which followed for over two hours.

During the evening Mr. Drummond-Jackson showed a short film on the use of a flange type of vestibular mouth pack.

Members of the medical or dental profession who are interested in joining this Society should write to its Hon. Secretary for full details of membership.

REPORT ON THE EDGEWISE APPLIANCE*

By J. R. HALDEN, L.D.S. R.C.S., B.D.S., D.Orth. R.C.S.

My interest in the edgewise appliance dates from the time that our President returned from the United States, and read a paper to this Society in which were the following words: "The Tweed philosophy is, very briefly, the extraction of four first premolars in a high percentage of cases, and the use of the edgewise arch. The space of the lower first premolars is partly closed by forward movement of buccal segments, and the anchorage so obtained is used to bring back labial segments and move distally, if necessary, the upper buccal segments. In capable and intelligent hands I believe that this method produces a higher percentage of successfully treated cases not requiring prolonged retention than any other philosophy at present in vogue in North America." Those words were particularly significant then, for they were spoken at a time, difficult to remember now, when the twin arch was still the latest thing in this country and considered by most as being the very last word.

It had been realized at that time (Ballard 1947) that the orofacial muscle pattern common to a high proportion of cases in this country does not permit the lower labial segment to be proclined and to remain stable. It followed that most cases with crowding in the lower arch would have to be treated by extraction, probably of first premolars, and it followed again that an appliance had to be found that could close the spaces from in front or from behind without allowing tilting and rotation of the teeth on either side of the extraction space. The extract from the paper that has been quoted seemed to point out the way to do this. The remainder of this paper will be an attempt to show how much progress has been made in the search for an adequate technique, and how that search was conducted.

Since dollar restrictions made purchase of the manufactured edgewise brackets, tubes, eyelets, and pliers impossible, it was decided to make the parts by hand and to obtain the pliers by modifying existing patterns. Fortunately it transpired that rectangular wire was being made here for export to Australia, so the most difficult problem of all did not have to be solved. Brackets were made from 1·5 mm. wire by cutting the bracket slots with a circular saw and the wings with a disk. The first case on which they were tried out was one for whom four sixes had been extracted, since this type had always presented problems of space closure and correction of tilts and rotations that were beyond the powers of simple appliances.

After making many hundreds of brackets by hand, it was decided to have them machine made out of stainless steel, and treatment then became much easier, if only because the bracket slot was henceforth at a more constant angle to the tooth surface. The results were encouraging, and many cases were successfully treated; but the method was very time-consuming. Text-books can teach one a basic technique, but not speed and dexterity. It was felt that a visit to the United States would be most valuable at this stage.

Accordingly, it was arranged that I should visit Tufts University School of Dental Medicine in Boston, and Northwestern University, and the University of Illinois School of Dentistry in Chicago. In addition, through the generosity of the Tweed Foundation for Orthodontic Research, it was arranged that I should call on its secretary, Dr. Herzberg, in Chicago, and then carry on to Tucson, Arizona, with a scholarship to take the 1954 Tweed teaching course there. The Eastman Dental Hospital generously made a contribution towards my expenses.

Upon my arrival in Boston, in March, 1954, Dr. Margolis and his staff made me very welcome, and I sat in on several seminars. Tufts is largely an edgewise school, though extra-oral traction and bite-plates are used quite a lot. Theirs is a simplified version of

* A paper read at the meeting of the British Society for the Study of Orthodontics, held on Feb. 11, 1957.

the Tweed philosophy, without the more complex anchorage preparation procedures. In common with many men on the East coast, they often like to have molar-width brackets on all bands except the anchor molars, so that staples are not necessary. I was to meet several of their instructors later as fellow-seminarists on the Tweed course.

From Boston I journeyed to Chicago and visited Dr. Thompson. He made me very welcome both in his office and at Northwestern University and he arranged for me to visit Dr. Brodie and Dr. Herzberg. All three men invited me to call in at their offices whenever I liked. Thompson uses the edgewise appliance in his own office and I noted especially that he uses buccal tubes both on the lower first and second molars of the same case. He feels that he obtains better anchorage that way. His practice is largely concerned with problems of bite analysis.

I watched Brodie at work in his office on several occasions. He uses precious metal bands *and* archwires, and treatment procedures that are perhaps more akin to Angle's than are most men's. He is loath to extract, and likes in suitable cases to expand the dental arches by bodily movement of the teeth with the edgewise arch, so as to make room for the alinement of the teeth, and then to leave out the arches and see if the case "pops". If it doesn't, he removes the bands; if it does, he takes out four premolars and the case is already half finished. I admit that I was sceptical of that last statement at the time, but since having had to carry out a similar procedure for a case referred to me from the States, by a man holding similar views to Brodie's, I have been surprised how quickly space closure can be accomplished when all the alinements, rotations, etc., have been attended to. Both Dr. Brodie and Dr. Renfroe, the instructor in technique at the School of Dentistry, treat their Class II cases by mass distal movement of the upper arch, using precious metal archwires. The second order or tip-back bends are so slight that they are barely visible, and they are not increased until it is apparent that distal movement has stopped. Class II elastics are used to a fully strapped-up lower arch.

With regard to expansion, Brodie felt that little is known about muscle growth, but that it *is* known that muscles will adapt themselves to an increase in length and change of function. Their development may lag behind that of the skeleton. Expansion may relapse if done too quickly for the muscles to adapt themselves, so it must be done gradually and with light force. He mentioned a paper by Walter (1951) on "Changes in the Form and Dimensions of Dental Arches Resulting from Orthodontic Treatment" for evidence that expansion quite often holds. He did say that he was unable to be sure beforehand when expansion would hold and when it wouldn't, but that one acquired an intuitive assessment of a case with experience. In this respect several men told me that it was easier to admire Brodie's own results than to equal them. I saw the models of several cases where expansion had held years out of retention. Dr. Downs, who has a tremendous reputation as an orthodontist, is much keener on extractions and is more inclined to the Tweed way of thinking. Unfortunately I saw less of him than I should have liked, because he only attended the school for two of the days out of my stay in Chicago. He was quite sure that the A point could be shifted posteriorly by correct edgewise arch technique.

Dr. Herzberg is the Secretary of the Tweed Foundation. He is a part-time teacher at Northwestern University. You will be familiar with his numerous papers on the use of the Tweed philosophy in practice and its effect on the profile. He uses stainless steel bands, and he was the only orthodontist I saw in action employing a technician. They mostly do their models and retainers themselves, and I often saw the method described by Tulley (1956) being used, but for routine rather than for temporary use. Herzberg does carry out the anchorage preparation procedures and does reduce bimaxillary proclinations with great benefit to the profile at the end of active treatment. He assured me he had no trouble with spaces reopening with these cases, even though he seldom places a retainer. He will be visiting us later on this year, and I hope he will bring some cases to show us.

From Chicago I left for Tucson, near the Mexican border, on the edge of the Arizona desert, to spend a week with Dr. Tweed prior to the course. This week was spent in strapping up my typodont, seeing patients under treatment, and in helping him with preparations. Everything possible to make my stay worth while was done. At the end of the week the six instructors arrived, soon followed by the thirty-six men and one woman taking the course, and on the appointed day the work began. We started at 8.30 each morning and finished, theoretically, at 5.30. In practice we never stopped before 11.15 at night, at which time we used to go round to our nearby motel and talk till midnight. There were many lectures and film shows, but, after a briefing in the morning, most of the time was spent working on our typodonts. There were long zinc troughs heated by gas for us to "dunk" our typodonts in, benches for us to work at, tracing tables, a lecture hall, and benches where one could solder. We were told that we were the largest class to date and the first one to finish within the scheduled time. Nowadays the classes are even bigger, for the April course of this year has fifty-six members, the total capacity for attendance, and a waiting list of over forty may have to be absorbed by an October course as well. Incidentally, Dr. Reidell was on this course. I compared our approach to diagnosis with his, and found that he is fully as interested as we are in physiology in relation to the aetiology of malocclusion, though he does not go quite as far as we do. I mention this because not all Americans are purely mechanical in their outlook. It would be truer to say, I believe, that they are more loath to commit themselves to print about concepts that, as we have found, are almost incapable of objective proof. I think we have blazed the trail in relating variations in soft-tissue morphology to specific malocclusions, but let us not fool ourselves that we are alone in the field.

In view of this American interest in Tweed and his work, I thought you might like to have some details of how he uses the edgewise mechanism. He is a brilliant, practical man, and whether he is right or wrong in his views, his technique is outstanding and can solve many of our problems for us. Moreover, please remember that he is interested above all in facial æsthetics; he is not concerned whether certain types of orofacial musculature will permit a stable proclination of the lower labial segment because he would dislike the effect upon the profile anyway. He will only compromise in extreme cases, ones that are beyond the scope of the elaborate technique he has evolved to put his concepts into practice.

Any discussion of Tweed's treatment procedures will involve descriptions of anchorage preparation as he understands it, so it will be as well if I try to clarify what he means by that term. I will quote: "By anchorage preparation I mean the placing of the mandibular incisors up over basal bone, or maintaining them on the basal bone, and arranging the axial inclination of the teeth in the buccal segments, from cuspid to second molar when possible, in such a manner as to create slightly distal-axial inclinations of the anchor molars, whether first or second molars." In other words he likes to tip back the teeth in the buccal segments until they are leaning away from the direction of pull and offering the same resistance to displacement as a tent peg does to its guy-rope. If you agree that it is better to finish your case with the teeth in the buccal segments upright or leaning slightly backwards in order to minimize the danger of the extraction space's reopening, then you will be wise to consider tipping them back *before* you start to pull on them because it is nearly impossible to tip them back *while* you are pulling them forward. If you tip them back first, you can, by slight increases in the tip-back effect of your archwire at each visit, ensure that the teeth remain tipped back, and hence that they have to be shifted bodily forwards by the displacing force if they have to give way at all. Tweed also likes to tip the lower incisors five degrees posteriorly beyond the angulation to the Frankfort plane that he wishes eventually to attain, because he likes to allow for the inevitable forward displacement of the whole lower arch under

Class II elastics that occurs no matter how perfect one's anchorage preparation has been. You have to make up your own mind about all this because opinion is not unanimous. No less an authority than Brodie maintains that the strongest anchorage is provided by teeth that have had only a minimum of "limbering up" to permit the placing of a heavy archwire, and hence a minimum of cellular reorganization around their roots.

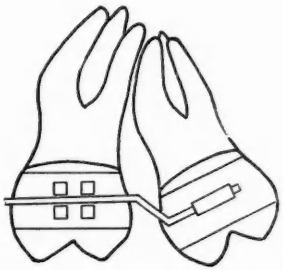

Fig. 1.—Tip-back bend (shown exaggerated for clarity) tipping an upper anchor molar distally, without traction.

To bring about this distal tipping of teeth, whether it be in the lower arch to prepare anchorage, or in the upper to retract all the teeth and correct a Class II condition, Tweed uses extensively a method of moving teeth that is peculiar to the edgewise appliance. This involves the distal tipping of whole arches or segments of an arch *en masse* by a combination of tip-back bends and elastic traction. A tip-back bend placed so as to act on the last tooth in an arch will usually move that tooth away from the tooth immediately mesial to it without other aid. (*Fig.* 1.) If a series of tip-back bends is joined together to act on every tooth in a buccal segment, it is possible to tip a whole buccal segment distally provided always that an external force is added to the archwire, usually Class II or Class III traction depending upon whether the upper or the lower arch is involved. With this force the teeth will tip back from a point somewhere near their apices in favourable cases (*Fig.* 2). Without it they will be more likely to tip around the point of application of the force, which is the bracket. If the whole arch is to be moved distally, a means must be found of applying a distal-tipping force to the incisors as well, and this should be in harmony with the distal-tipping force on the teeth in the buccal segments. Since the labial segment of the archwire lies approximately at right-angles to the buccal segments and to the sagittal plane, the tip-back effect will have to be bent into the cross-section of the wire instead of into the length of the wire if it is to maintain the same

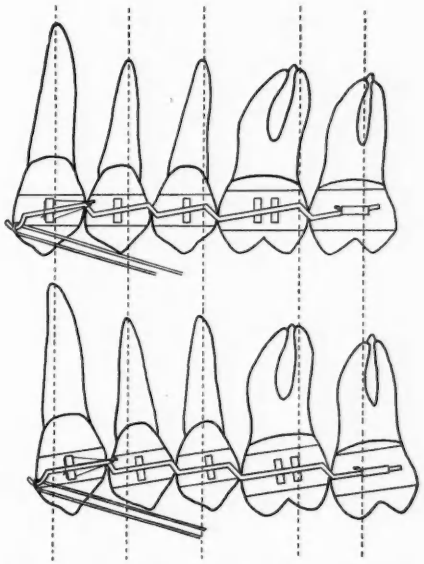

Fig. 2.—Tip-back bends plus Class II traction tipping the crowns of an upper buccal segment distally without forward movement of the apices.

direction. This is effected by seeing that there is lingual crown torque in the labial segment. (*Fig.* 3.) Tweed uses this movement regularly in the lower arch as well to prepare anchorage, for it both moves the crowns of the teeth posteriorly and gives them the distal axial inclination to resist pull that he desires; however, when he moves a whole upper arch distally to correct a Class II condition, once the upper incisors have been tipped to an æsthetically satisfactory inclination, at that point good mechanics is ignored and palatal root torque is substituted for palatal crown torque so as to prevent the upper incisors

from "rabbiting in" during the remaining distal movement; increased use of the head-gear plus Class II traction supplies the extra posterior-displacing force now required. He uses this mass movement of arches to correct non-extraction cases, and to correct extraction

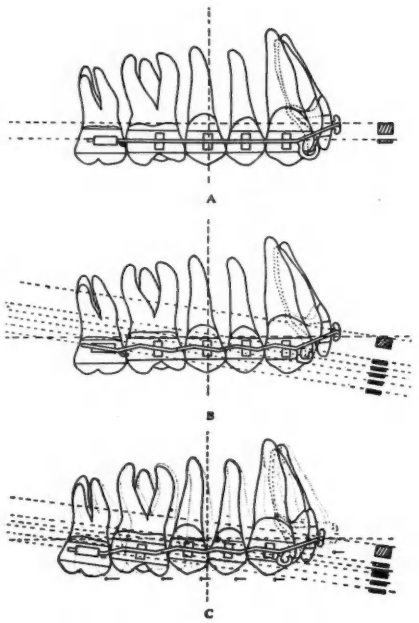

Fig. 3.—A, Arch wire in passive state; B, Correct co-ordinated second-order bends with incised torque; C, Illustrates action when intermaxillary force is applied to co-ordinated bends.
(*By courtesy of Dr. Charles Tweed and "The Angle Orthodontist".*)

cases after all the extraction space has been used up. In other words, if you have used up all your extraction spaces and there is still an overjet, the case may still respond to treatment as though it were a non-extraction case. With other appliances there is little else you can do.

With that introduction, I should like to describe how Tweed would treat the type of case mentioned at the beginning of this paper, a four premolar extraction case. As you will see, to try to cover the treatment in detail of all classes, extraction and non-extraction, would be an imposition upon your powers of endurance. Let us imagine that it is a difficult case, one requiring that two-thirds or more of the extraction spaces must be used up *from the front*, leaving only one third or less of the space for harmless anchorage shift in the buccal segments. As you know, Tweed likes to end up with the lower incisors at an angle of 65° to the Frankfort plane because he likes the rather straight American cover-girl profile that such an angle tends to give, especially if it is associated with a low Frankfort-mandibular plane angle. This often means converting a mild overjet into a large one with subsequent bodily movement of the upper incisors to reduce it. Speaking for myself, and leaving aside considerations of æsthetics for a moment, I often try to do the same thing in order to reduce the degree of bimaxillary proclination of a case having incompetent lips, hoping that the competence or near-competence thus made possible will be in effect a new position of muscle balance and labial segment stability. If the profile is improved in the process, no one is more pleased than I.

To continue with the technique. After separation, all the teeth are banded, including the second molars if erupted. If the incisors are very imbricated, two only are banded at first, leaving the other two until room has been made by retraction of the canines. The bands are of precious metal and carry standard edge-wise brackets together with eyelets placed as far mesially and distally as the adjoining teeth will permit. The upper central incisors carry double-width brackets, and the first molars, when not the anchor molars, carry two standard brackets placed about $\frac{1}{8}$ in. apart. The anchor molars carry rectangular tubes and sometimes soldered hooks as well. (*Fig.* 4.)

The first step will be to level off the brackets so that the heavier rectangular wires may be sprung in without too much strain. Usually an 0·018 in. (i.e., 0·45 mm.) round arch is placed to accomplish this, and any rotations or slight buccolingual movements as well. Like all the archwires to be described, this one is of stainless steel, heat-treated, and polished. Every attempt is made to avoid proclination of the

incisors during this procedure, and it must be emphasized that the archwires are shaped to the malocclusion as much as it is required, with no similarity to the automatic rounding and proclining effect of the twin arch. Uprighting of the teeth in the buccal segments is started now, if they are at all tipped forwards,

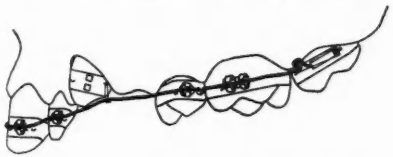

Fig. 4.—Initial correction of rotations and discrepancies in a vertical plane with a light round archwire.

by bends in the archwire. After three or four weeks, 0·019×0·026 in. (roughly 0·5×0·65 mm.) upper and lower arches are fitted (*Fig.* 5) carrying soldered horizontal loops;

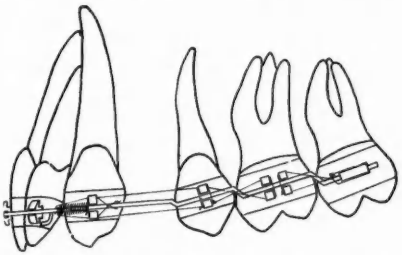

Fig. 6.—Appliance adjustment for the distal movement of upper canines with the aid of coil-springs.

note that the archwire is bent free of the canines and that the mesial arm of the loop is tied to the distal eyelet on the canines by the activating ligature; by this means the canine is free to tip distally and the tendency to rotate is minimized since the line of action passes nearly through the middle of the tooth. The headgear is used to the lower arch. When the canines have been moved distally until they are at right-angles to the occlusal plane, further retraction is postponed until the teeth in the buccal segments have been tipped distally into anchorage-prepared positions, unless the case is a simple one with residual spacing. The upper arch is prepared to withstand the pull of Class III elastics by the fitting of an 0·0215×0·027 in. heavy stabilizing arch with mild tip-back bends in the buccal segments to hold them from tipping forwards, plus tie-back stops against the buccal sheaths

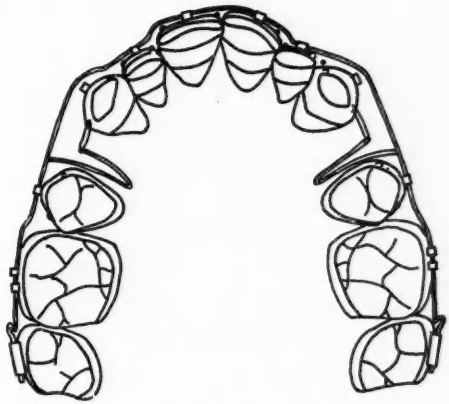

Fig. 5.—Appliance to tip upper canines distally until their long axes are at right-angles to the occlusal plane.

and anterior brass hooks for the headgear attachment. It is tied back hard to bind the arch into a solid unit. The teeth in the lower

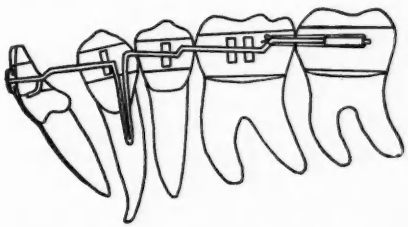

Fig. 7.—Lower Bull loop appliance for posterior movements of the labial segment. The tip-back bends in the buccal segments are bent immediately distal to the brackets to permit distal movement of the archwire under ligature traction.

buccal segments are tipped distally by fitting a working archwire (henceforth the 0·019×0·026 in. wire will be referred to as "working" and the 0·0215×0·027 in. wire as "stabilizing"), and this working archwire carries tip-back bends on the premolars and molars. The latter are induced to slide distally down the tip-back bends lying across their brackets by means of Class III elastics attached anteriorly

to sliding jigs, which are really a form of extended sliding hook made by bending short pieces of archwire to slide along the main archwire and press against the second premolars. Forward displacement of the upper arch is minimized by wearing the headgear for at least fourteen hours out of every twenty-four. When the lower buccal segments have been tipped well back, the mechanics are reversed. A heavy stabilizing archwire is fitted to the lower arch tip-back bends and sliding jigs, activated by Class II elastics, take back the upper buccal segments into anchorage-prepared positions.

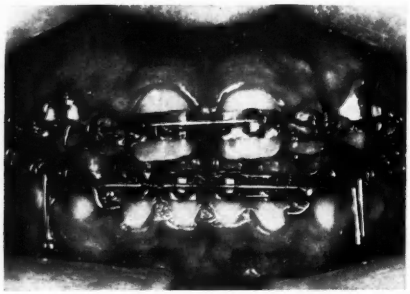

Fig. 8.—Lower Bull loop appliance adjustment shown with Class III elastics in place.

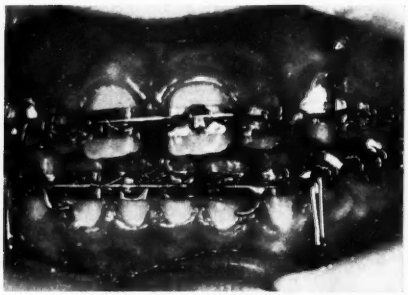

Fig. 9.—As in *Fig.* 8, but with an elastic removed to show a loop.

With the canines upright and the teeth in the buccal segments in anchorage-prepared positions, the distal movement of the upper and lower canines is continued by fitting upper and lower working arches carrying short lengths of open coil spring (*Fig.* 6). The archwires engage the canine brackets this time, the coil springs are activated by ligatures, and the canines are moved in an upright position as far distally as it is required. Should they take a distal tilt, the archwire is bent to move the apices distally while the coil springs hold the crowns from coming forward again. Once they are upright, the archwire is made straight again and retraction is continued.

With the canines back the required distance, all that remains now is to retract the upper and lower labial segments. The lower is retracted first, and this is done by fitting a lower Bull loop arch (*Fig.* 7) made from working archwire. Note that it is bent free of the canines, that the mesial leg of the loop is shorter than the distal so as to depress the labial segment and that the loop is activated by tying a mesially placed tie-back stop to the distal of the buccal sheath so that it is pulled backwards. Hooks are soldered to the labial section of the arch, and the Bull loops, plus Class III elastics from an upper stabilizing arch plus headgear, as before, rapidly take back the labial segment as far as it is desired. *Fig.* 8 shows the case at this stage, and *Fig.* 9 the same case with an elastic removed for clarity. Tweed likes to take back the lower incisors to at least 5° beyond 65° to the Frankfort plane, i.e., to at least 70°, as already stated. An ideal lower stabilizing size archwire now replaces the Bull loop archwire and Class III mechanics is continued until anchorage is well set up again in the lower arch. The lower archwire is then tied back hard to make it ready to receive the pull of Class II elastics.

The lower arch will now be used for the final retraction of the upper labial segment. Mechanics will be reversed once more, and Class II traction will replace Class III traction. With the retraction of the lower labial segment, the overjet will of course have been increased, but every effort will be made to maintain the lower incisors where they are. An upper Bull loop arch is fitted, and this, plus Class II elastics, is used to retract the upper incisors—but only until they are at an æsthetically satisfactory inclination to the vertical; from then on the Bull loop arch is discarded and

mechanics designed to maintain this æsthetically satisfactory axial inclination is substituted. In other words, bodily movement of the upper incisors must now be attempted if an overjet still remains.

The Bull loop arch is now replaced with a free-sliding stabilizing-size upper ideal archwire that will fit the bracket slots of the anterior teeth quite closely. (*Fig.* 10.) This absence of play is necessary because the labial segment carries strong palatal root torque so as to prevent the upper incisors from "rabbiting-in". It is bent quite free of the canine brackets, but in the buccal segments it is reduced to $0{\cdot}018 \times 0{\cdot}024$ in. in the anodic polisher so as to facilitate the free-sliding action through the brackets. The tip-back bends are carefully placed so as not to impede this distal-sliding movement, and, as you can see, intramaxillary traction from coil springs acting on stops soldered mesial to the premolar brackets is used to supplement the strong Class II traction and above all headgear traction that is essential at this stage. In Tweed's hands this method is so effective that he has to pay special attention to seeing that the upper incisor apices do not go through the palatal wall. If any spacing remains in the lower arch, advantage is taken of this to keep the lower incisors from proclining under the pull of the Class II traction, and this is done by having the lower tie-back stops on the lower arch placed a few millimetres mesial to the buccal sheaths and by cinching back hard at each visit so as to pull the incisors back the amount that traction has just displaced them forwards.

With the overjet corrected, fresh upper and lower ideal arches are fitted, and intramaxillary traction in both arches by means of open coil springs to forward stops is used to close any remaining spaces. These arches have been placed one on top of the other and carefully correlated bucco-lingually before being tied in. They also carry soldered vertical spurs so that up and down elastics may be worn to seat the cusps properly should that be necessary.

The bands are stripped in two stages; first the canine, premolar, and first molar bands are removed and intramaxillary traction continued until the band spaces have been eliminated; secondly, the remaining bands are stripped and impressions are taken for retainers. The spaces left by removal of the four incisor bands are closed immediately prior to taking the impressions, with two small wedges, and the spaces thus opened up just mesial to the canines are utilized for passing the rectangular labial bow of the Hawley retainers from front to back. Cases are retained full time for one year and then at night for a further year.

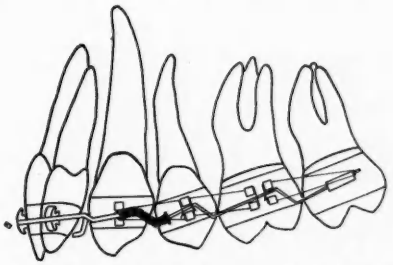

Fig. 10.—Appliance adjustment for the final posterior bodily movement of the upper incisors. The archwire is bent free of the canine brackets, and the tip-back bends are increased so as to maintain axial inclinations despite the reduction in size in the anodic polisher.

SUMMARY

The edgewise is the most dangerous of all appliances in inexperienced hands, but when properly used it provides the best answer that we have to the treatment of the more difficult case. It can control the position of every tooth in the arch, and if a movement is possible at all, the determining factor is likely to be the skill of the operator rather than the limitations of the appliance. Its disadvantages are chiefly related to time. The time required by the patient to keep it clean, and the time taken by the operator to adjust it, with consequent limitation of the number of cases that can be treated. The first is not really a problem, and the second is something more related to economics than to orthodontics.

Case reports were shown, of representative extraction cases that had been treated within the last two and a half years. None were out of retention, so no claims were made

that the results were stable. The fact that they had mostly been treated according to Tweed's technique is incidental in this connexion. The aim was simply to show what tooth movements the appliance had brought about in the author's hands, so that the Society might have an idea of what it might achieve according to the philosophy and in the hands of a Tweed, of a Downs, or of a Brodie.

These cannot be included here but will be published separately.

Acknowledgements.—I should like to thank Dr. Charles Tweed for permission to describe the treatment procedures that are taught at his seminars, Professor Ballard for placing the facilities of his department at my disposal and for permission to show slides of those cases that were under treatment in his department, and Mr. W. J. Morgan, A.R.P.S., of the Eastman Dental Hospital Department of Photography for his skill in taking most of the photographs and preparing the slides.

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ABSTRACTS FROM OTHER JOURNALS

Recent Advances in the Diagnosis and Treatment of Hæmophilia

Two hundred patients with constitutional hæmorrhagic diathesis have been seen and the following observations are made: (*a*) Ten per cent of patients suffer from Christmas disease; (*b*) Fifty per cent of patients gave no history of any other affected person in the family; (*c*) The cause of defective coagulation is the deficiency in or absence of antihæmophilic globulin (A.H.G.) which is measurable; (*d*) Hæmophilia can be severe or mild, the latter having history of definite trauma such as a dental extraction; (*e*) The level of A.H.G. in mild cases varies from 1 to 30 per cent; (*f*) Patients with more than 15 per cent A.H.G. do better than those with less than 10 per cent; (*g*) A.H.G. is very unstable in human plasma; (*h*) Plasma used for treatment must be fresh; (*i*) Plasma and blood transfusion cannot raise the A.H.G. level of a severely affected patient to normal range.—BIGGS, ROSEMARY (1957), *Proc. R. Soc. Med.*, **50**, 645.

Some Clinical Applications of the Modified Johnson Twin Arch Wire Technique

The modified twin arch wire technique aims at a more efficient method of retracting canines in extraction cases, reinforcement of intra-oral anchorage, and better control of the premolars and the lower incisors. Canines are retracted by sectional appliances made from end tubing and ribbon-shaped wire. Force may be obtained by compression or extension of coil-springs or the use of rubber elastics.

The maxillary lingual arch wire may be modified by the addition of a palatal button of acrylic fitted against the vertical portion of the tissues of the anterior hard palate. Extra-oral anchorage may be used to reinforce the sectional arches when the latter carry a double tube attachment.

The headgear is constructed from plastic tubing and plastic belting. The twin wire arch is often succeeded by a series of light round wires of increasing diameter. Space-closing loops and uprighting and rotating springs may be added to the appliance.—WEBER, F. N. (1957), *Amer. J. Orthodont.*, **43**, 90.

A Simple Technique for Making Dental Porcelain Jacket Crowns

In this technique a stock porcelain tooth is selected to suit the patient. The back of the tooth is hollowed out to fit round the prepared tooth-stump and the facing thus made is fabricated into a jacket crown using a low-fusing porcelain.

By this means many of the difficulties of making normal porcelain jacket crowns are overcome such as colour and translucency matching, size and shape reproduction, time, and skill factors.

An outline of the technique is: (1) A classical shoulder crown preparation is used.

(2) A stone model of this is obtained from a standard indirect copper band impression. (3) Gold foil is burnished on the model as a matrix for the porcelain. Low-fusing porcelain allows gold to be used. (4) The veneer is prepared from a stock tooth using diamond stones. (5) A mixture of low- and high-fusing porcelain is prepared. The high-fusing porcelain is obtained from powdered old porcelain teeth. Thus in the baking only the low-fusing porcelain melts and the total shrinkage is reduced. (6) This mixture is painted around the tooth preparation and the veneer is placed in position. Alinement is checked and then follows the first bake. (7) Adjustments are made, contact areas are checked, and lingual contouring is done. The second and final bake is then performed.—SACCHI, H., and PAFFENBARGER, G. C. (1957), *J. Amer. dent. Ass.*, **54**, 366.

BOOK REVIEWS

A MANUAL OF STOMATOLOGY. By J. P. WALSH, M.B., B.Sc., D.D.Sc. (Melb.), L.D.S. (Vic.), F.D.S. R.C.S. (Eng. and Edin.), Professor of Dentistry, Dean and Director, University of Otago Dental School, Honorary Dental Surgeon, Dunedin Hospital. With a Foreword by Sir Charles Hercus, D.S.O., O.B.E., Dean of the Medical Faculty, University of Otago Medical School, Dunedin, New Zealand. $7\frac{1}{2} \times 4\frac{3}{4}$ in. Pp. 130 + xii, with 37 illustrations. 1957. Christchurch, New Zealand: N. M. Peryer Ltd. 30s.

THIS book is based on a series of ten lectures given by the author to undergraduate medical students of the University of Otago to acquaint them with the broad principles of stomatology. The book does not claim to teach details.

The general philosophy presented is extremely sound and any reader who is a member of either the dental or medical profession will find the chapter devoted to oral diagnosis most useful.

Much attention is given to what the author chooses to term "The Oral Aspects of Personality". Several extremely illuminating and interesting case histories are presented which draw attention to a facet of dentistry which has tended to be neglected.

Other subjects briefly presented in the book are the oral manifestations of systemic disease; medical conditions affecting dental treatment; oral lesions requiring medical treatment; management of some specific oral conditions; extractions and anæsthesia and preventive dentistry. The book commences with short sections on embryology, anatomy, histology, and physiology, followed by pathology and bacteriology.

The book is presented on good quality paper, suitably bound for its size, and the illustrations are clear and informative, except for the intra-oral pictures which have printed very darkly and consequently obscure the detail.

This book can be confidently recommended to all medical practitioners who wish to have a more enlightened appreciation of the oral cavity and its problems in association with the body as a whole, although it seems a little unfortunate that it is not possible to publish what is little more than a pocket-book at a price less than thirty shillings. A. B. W.

ORAL DIAGNOSIS AND TREATMENT (Oral Medicine). By SAMUEL CHARLES MILLER, D.D.S., F.A.C.D., F.A.D.M., Professor of Periodontia and Oral Medicine, Chairman, Department of Periodontia and Oral Medicine, New York University College of Dentistry, and thirty-seven contributors. With an Introduction by Raymond J. Nagle, D.M.D., F.A.C.D., Dean, New York University College of Dentistry. Third edition. $9\frac{1}{4} \times 6\frac{1}{4}$ in. Pp. 977 + xx, with 607 illustrations, 30 in colour. 1957. New York and London: McGraw-Hill Book Co. Ltd. 120s.

IN its third edition *Oral Diagnosis and Treatment* makes a very welcome appearance. It has new chapters on the surgical management of oral disease; aetiology of periodontal disease; partial denture design and planning;

aviation dentistry; pain of dental origin; hyperplasia; benign tumours and cancer of the oral cavity; diagnosis of pulp abnormalities and their treatment; and diseases of the oral mucous membranes exclusive of malignant neoplasms.

An outstanding new feature of the third edition is the chapter entitled "Identification Keys as Diagnostic Aids". These keys enable one to arrive at a diagnosis easily and quickly. This is a useful and desirable guide and will have to be used intelligently.

All the thirty chapters have a questionnaire and bibliography at the end of each of them which helps one to refresh the memory and dive into further relevant knowledge. Some of the illustrations have not been reproduced to the best advantage and it is hoped that the next edition will take care of this. There are thirty-eight contributors to this book who must be congratulated for their joint effort.

The objective of this book is to provide all that the dental practitioner and student would need to know about the oral cavity and its adnexa and for that reason should be in the hands of everyone who has to deal with dental problems. H. M.

ORAL HISTOLOGY AND EMBRYOLOGY. Edited by BALINT J. ORBAN, Loyola University, School of Dentistry, Chicago, Illinois. Fourth edition. $10\frac{1}{4} \times 7$ in. Pp. 379, with 269 illustrations, including 4 in colour. 1957. London: Henry Kimpton. 65s.

SINCE its first appearance thirteen years ago the popularity of this book has steadily increased, and the arrival of a fourth edition will be welcomed with approval and interest. The contributors to the latest edition now number sixteen, the new contributors being A. L. Ogilvie and F. M. Wentz, both from universities in the United States.

The general arrangement of the book remains unaltered from that of earlier editions, but the text has been modified or expanded where appropriate.

The editors have in general succeeded in their aim to provide a simple presentation of subject matter. However much a book may be commended, there are always small points that a reviewer can find to grumble about. This book is no exception, for here and there are a few scattered alterations in the new edition which might confuse rather than simplify understanding. Perhaps in future editions, in the chapter on enamel development for example, a more complete explanation could be given for the need to use, presumably for the same structure, the terms "epithelial dental organ" as a sub-title, "dental organ" in the text, and "enamel organ" in the caption for the illustration. Among the illustrations retained from earlier editions, it is questionable whether the drawings of test-tubes which hold the root canal preparations contribute anything very useful to the anatomy of root canals. Some of the new illustrations are electron micrographs which do much to enhance the chapters on enamel and dentine.

As the authors point out they are aware of the difficulties of introducing controversial topics in a work designed to serve a didactic purpose. Presumably, with this latter purpose in mind, the authors have in many places dealt with controversial issues inadequately. This certainly lessens the value of the book to teachers. The chapter on the innervation of dentine may be cited as an example. This extraordinarily complex problem, which has been a subject of disagreement for many years, is dismissed in approximately two hundred words. It is questionable whether omission of a discussion of the evidence for and against controversial topics is wise, or indeed desirable, for a work written for undergraduates. After all, the purpose of education is to persuade the student to think and to evaluate evidence for himself, rather than to convert him to predigested dicta which may rapidly become obsolete.

However, this is not intended to be a "critical" review, indeed there is little one can find to be really critical about. There is no doubt that this book will continue to be the standard text-book of dental histology. The editor, the contributors, and the publishers are to be congratulated once more on their achievement. R. W. F.